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ERIE COUNTY

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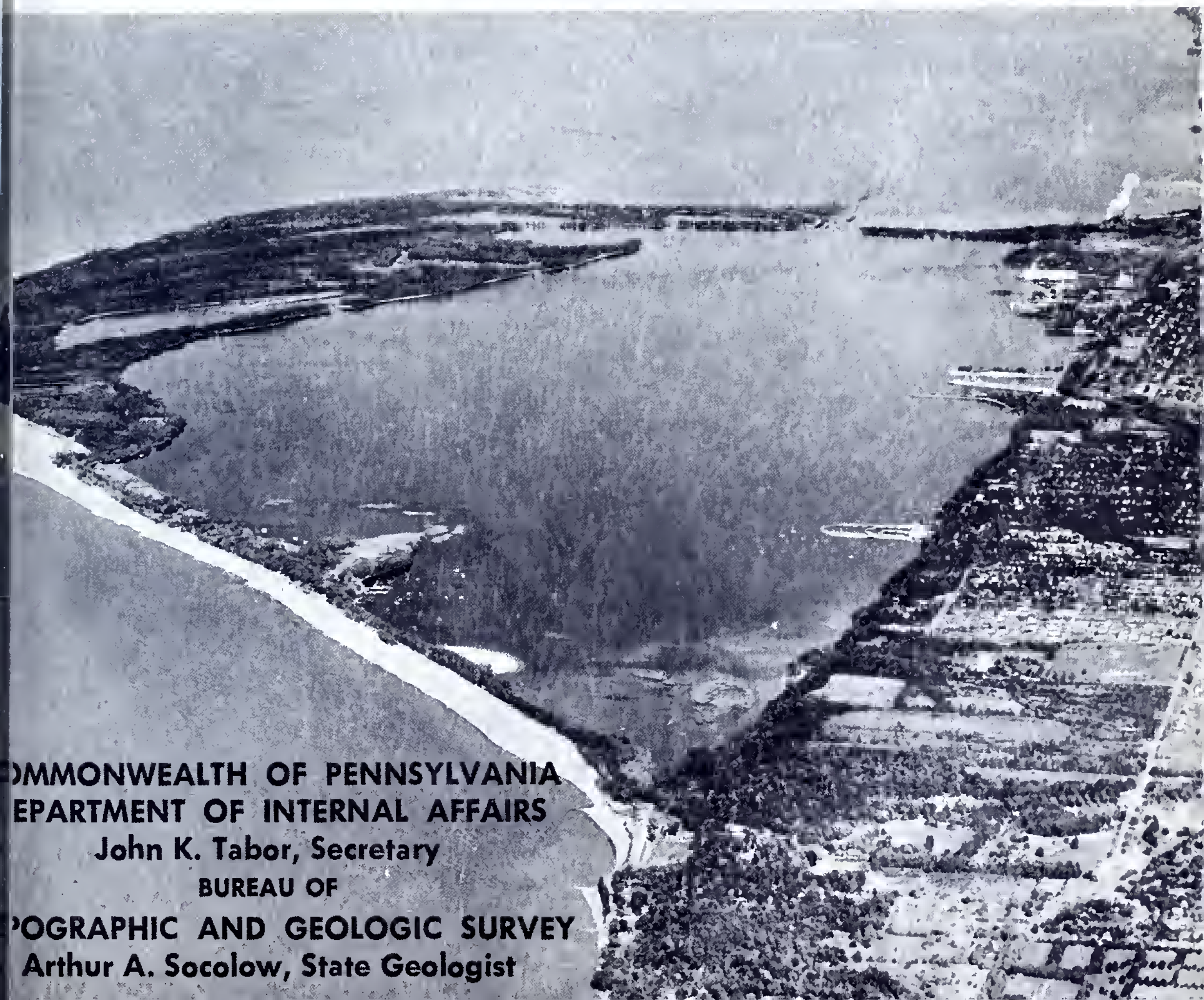

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Aerial view of Presque Isle, Erie County. Photo from Tourist and Convention Bureau, Division of Greater Erie Chamber of Commerce.

INFORMATION CIRCULAR 56

The Geography and Geology of Erie County, Pennsylvania

by John C. Tomikel and Vincent C. Shepps

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The Geography and Geology of Erie County, Pennsylvania

By
John C. Tomikel
and
Vincent C. Shepps

INTRODUCTION

This booklet has been prepared so that the students and citizens of Erie County, Pennsylvania may have a guide to the origin, composition, and resources of their environment. It is an introduction to the geography and geology of an important area of the Commonwealth and is intended to be of particular use to the educational institutions in the area.

Most of the information presented here has been compiled from published sources, but some is supplemented by field work by the authors. Every attempt has been made to make the content as factual as possible. Scientific or technical language which would pose difficulties for the lay reader has been avoided wherever possible, though use of such language cannot be avoided entirely.

LOCATION OF ERIE COUNTY, PENNSYLVANIA

Erie County is Pennsylvania's northwesternmost county and affords the Commonwealth its only frontage on the Great Lakes. Though Erie County's northern border ends at the lake line, the boundaries of the Commonwealth extend to the midline of the lake. The mineral rights for the area of Lake Erie are controlled by the Pennsylvania Department of Forests and Waters.

Figure 1 shows the location of Erie County in relation to adjoining counties and states and shows that it falls partly in the Appalachian Plateau physiographic province and the Central Lowland province. The intersection of 80° West longitude and 42° North latitude falls within the county as shown on Figure 4.

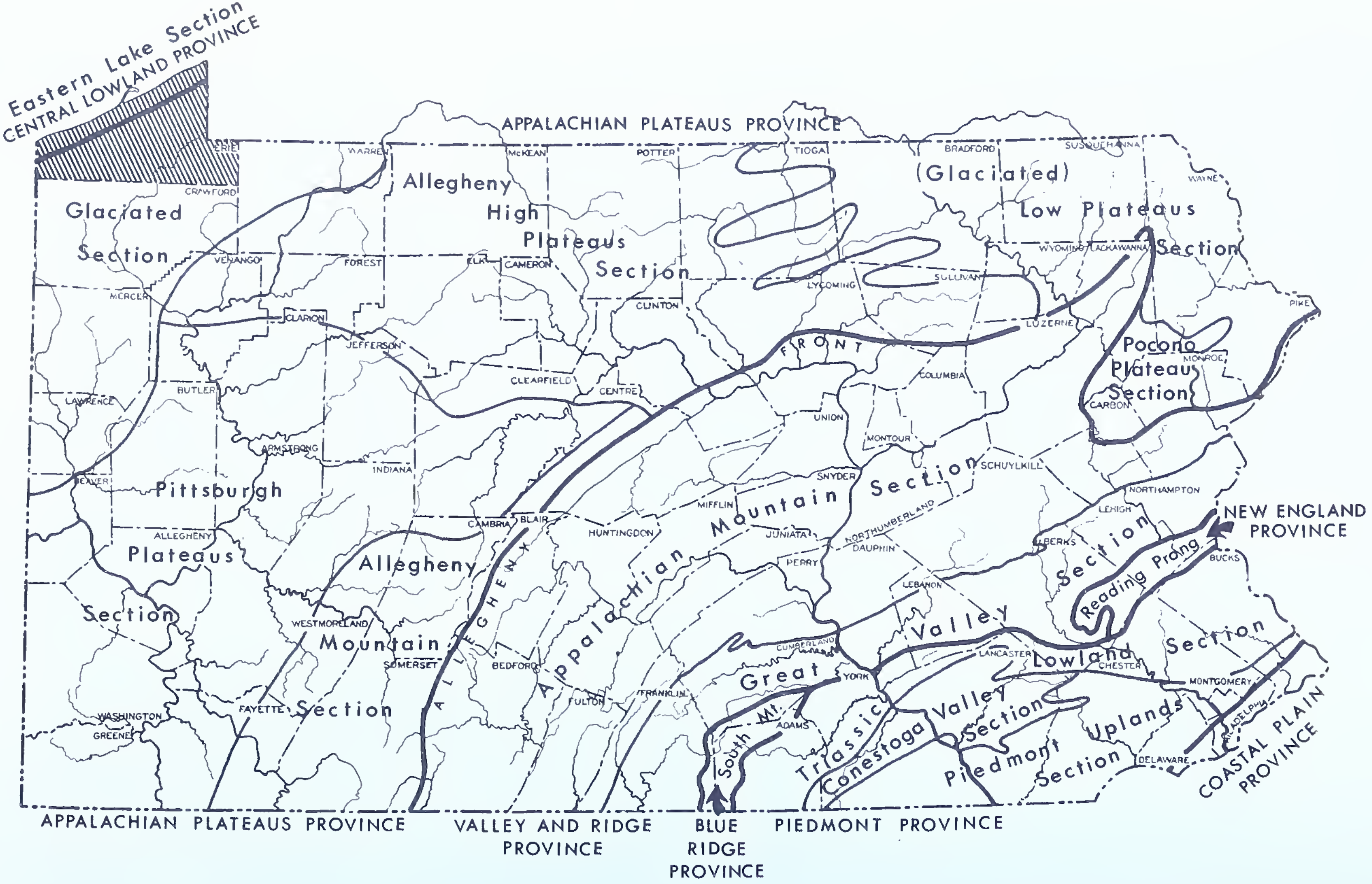


Figure 1. Erie County, Pennsylvania's northwesternmost County, includes parts of the Central Lowlands and Appalachian Plateaus physiographic provinces.

THE GEOGRAPHY OF ERIE COUNTY

Erie County has the distinction of having served under three flags. It was first owned by France when that country occupied the St. Lawrence River valley. Following the French and Indian wars the area was taken over by Great Britain. Great Britian lost her claim to the area during the Revolutionary War and it has since been under the flag of the United States. Erie County was organized on March 12, 1800 after remaining acreage in northwest Pennsylvania north of the 42nd parallel including Presque Isle was purchased from the Indians in the so-called "Purchase of the triangle" on March 3, 1792. The name "Erie" was the name for one of the Iroquoian families of North American Indians.

Erie County serves as a connecting crossroads between the east and the west of the Great Lakes region. Major highways and railways parallel the lake as they cross the county (see Figure 16). The county boasts Pennsylvania's only lake port and is the State's gateway to the St. Lawrence seaway and foreign shipping. Shipping facilities are furnished by the city of Erie which is located halfway between the state borders of New York and Ohio. Erie County has a forty-four-mile shoreline, excluding that of the eight-mile-long Presque Isle.

More than 80 percent of the county's 250,000 population was classed as urban dwellers by the 1960 census. Of the 812 square miles of area within the county, three-fifths is classed as farmland containing 2,511 individual farms. Almost half of the population lives in the city of Erie (138,440). Corry, the only other city in the county, has a population of 7,744. The civil divisions of Erie County and their populations are shown in Figure 2.

Most of the labor force is employed in the iron, electric-equipment, and light-machinery industries. A majority of farm owners operate their farm part time while also maintaining jobs in one of the county's sixteen boroughs or in Erie or Corry.

The climate of Erie County is classed as a cool Humid Continental. The average annual precipitation is forty inches which is spread quite uniformly throughout the year. Average annual temperature is 49 degrees Fahrenheit; the summer average is 68 degrees; the winter average is 28 degrees. In a 5-mile band along the lake the climate is clearly influenced by the presence of the large body of water. The effect is to retard both the start and the end of the growing season. Ten to fifteen miles from the lake the effect disappears entirely.

The land surface is of variable maturity and strongly reflects the influence of recent glaciation. The basic surface features, i.e. the lake plain giving way southward to an escarpment topped by a rolling upland, can be traced to the influence of bedrock of different hardnesses and

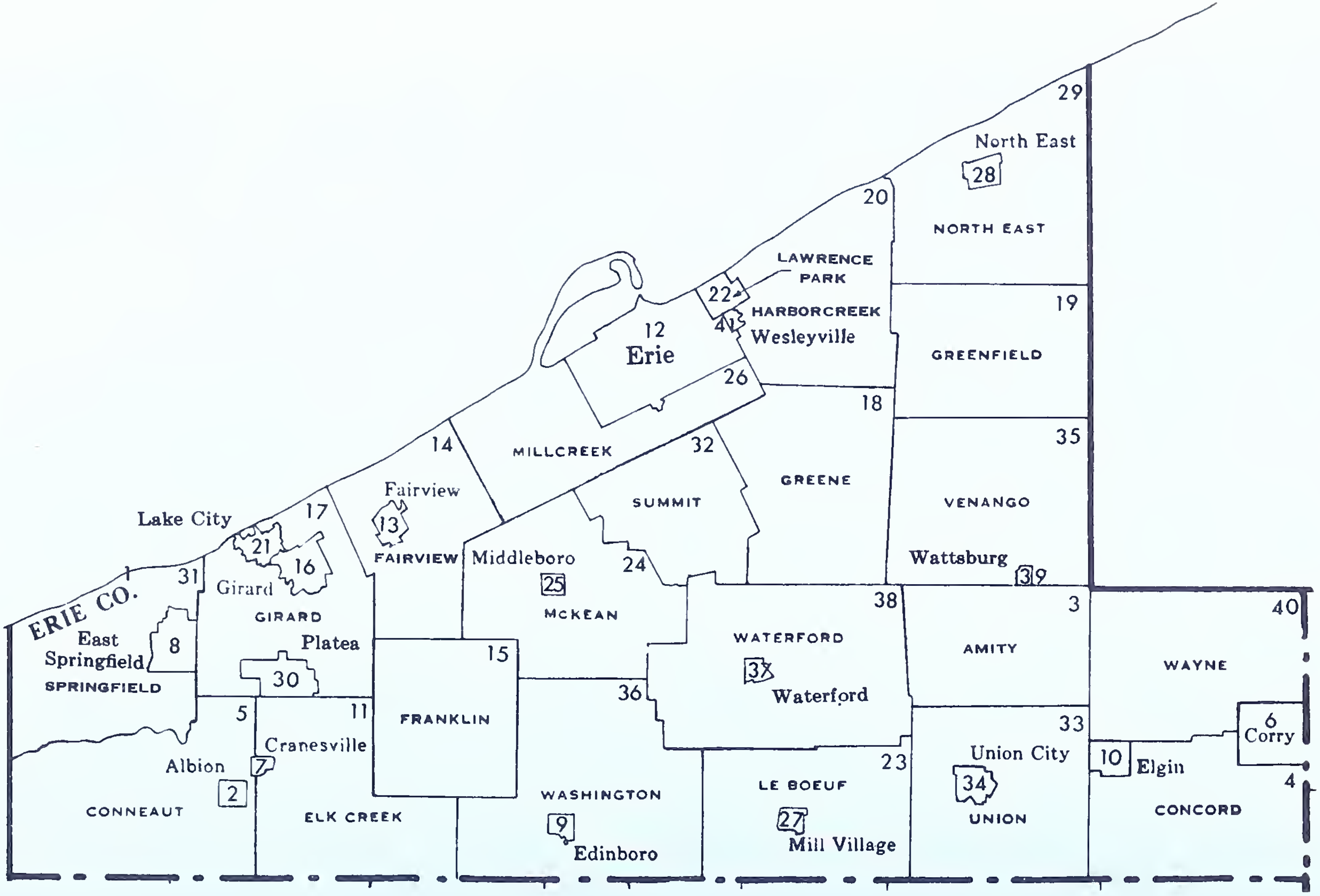


Figure 2. The civil divisions in Erie County and their populations as of 1960 census.

POPULATION OF ERIE COUNTY

	1960	1950	1940
1. Erie County	250,682	219,388	180,889
2. Albion Boro	1,630	1,729	1,604
3. Amity Twp.	739	748	713
4. Concord Twp.	1,126	948	868
5. Conneaut Twp.	1,734	1,462	1,374
6. Corry City	7,744	7,911	6,935
7. Cranesville Boro	575	602	548
8. East Springfield Boro	511	499	415
9. Edinboro	1,703	1,567	804
10. Elgin Boro	218	202	224
11. Elk Creek Twp.	1,209	1,202	1,210
12. Erie City	138,440	130,803	116,955
13. Fairview Boro	1,399	697	555
14. Fairview Twp.	3,887	2,328	1,479
15. Franklin Twp.	790	769	759
16. Girard Boro	2,451	2,141	1,732
17. Girard Twp.	2,432	2,149	1,552
18. Greene Twp.	3,080	2,166	1,516
19. Greenfield Twp.	926	983	854
20. Harborcreek Twp.	10,569	7,475	3,602
21. Lake City Boro	1,722	1,369	1,108
22. Lawrence Park Twp.	4,403	4,154	3,120
23. Le Boeuf Twp.	1,013	960	896
24. McKean Twp.	2,051	1,563	1,360
25. Middleboro Boro	442	379	320
26. Middlecreek Twp.	28,441	17,037	7,444
27. Mill Village Boro	336	324	259
28. North East Boro	4,217	4,247	3,704
29. North East Twp.	4,093	3,083	2,400
30. Platea Boro	357	290	281
31. Springfield Twp.	2,132	1,775	1,394
32. Summit Twp.	3,424	2,240	1,321
33. Union Twp.	1,430	1,307	1,172
34. Union City Boro	3,819	3,911	3,843
35. Venango Twp.	1,305	1,191	943
36. Washington Twp.	1,906	1,648	1,374
37. Waterford Boro	1,390	1,195	804
38. Waterford Twp.	1,737	1,486	1,280
39. Wattsburg Boro	401	343	290
40. Wayne Twp.	1,306	1,092	959
41. Wesleyville Boro	3,534	3,411	2,918

structures. The details of the surface itself reflect modifications impressed upon the countryside by repeated visits of a continental ice sheet in ages past.

Streams flow both north and south from a drainage divide which trends diagonally across the county. North-flowing streams drain into Lake Erie and thence out the St. Lawrence River to the Atlantic Ocean. South-flowing streams find their way to the Atlantic Ocean also, but do so by a route down the Allegheny, Ohio, and Mississippi Rivers. The bedrock of the county, nearly everywhere buried beneath the deposits of the glaciers, consists mostly of shales and thin sandstones deposited during the Upper Devonian and Lower Mississippian Periods of geologic time. The strata appear to be nearly level, but have a measurable tilt toward the south-southwest at about 20 feet to the mile.

The most valuable mineral products sold in the county in 1964 were sand and gravel followed by peat. Erie County ranked second in Pennsylvania in the production of sand and gravel in 1964. Some stone is quarried for road fill and natural gas is produced from both shallow and deep sands. Brine is produced for use in snow removal from highways.

The best known attraction in Erie County, especially to tourists, is the long, curved sand spit in Lake Erie known as Presque Isle. The peninsula containing 3,100 acres of land is an attraction to swimmers, boaters, fishermen, and naturalists. It also shelters the harbor of Erie. Presque Isle, which officially became "The Pennsylvania State Park at Erie" in 1929, hosted 3,351,505 visitors in 1965.

THE LAND SURFACE AND ITS USE

Erie County falls within two different physiographic provinces — the Central Lowland province and the Appalachian Plateau province (Figure 1). Land within the first province is low in elevation and relief and because it lies along Lake Erie has been called the *lake plain.* South of the lake plain and covering the southern two-thirds of the county is land of notably higher elevation and of a rolling character that can be called the *upland plateau.* Between the two areas is a narrow strip of sloping land which connects the low elevations of the lake plain with the higher elevations of the upland plateau. This strip of land may be called the *escarpment slope.* The distribution of the three land areas in the county is shown in Figures 3 and 4.

The Lake Plain

The lake plain borders the lake and extends southward for a varied distance of two miles in the eastern portion of the county and five miles in the western portion. Its elevation starts slightly above the lake level

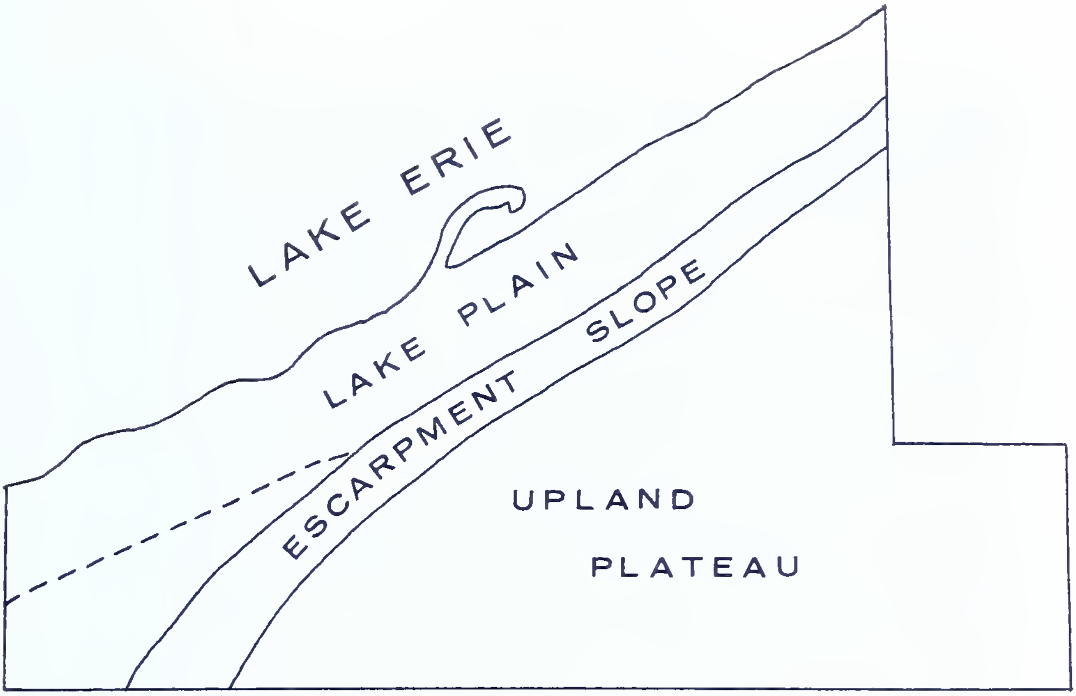


Figure 3. Sketch map showing the major divisions of Erie County's land surface.

of 572 feet and extends upward to approximately 800 feet above sea level. The lake plain terminates along the lake edge as a cliff which rises locally 80 or more feet above lake level, the highest portions being near North East and northwest of Girard. The face of the cliff exposes glacial drift, mostly till, over most of its length (Figure 5) and exposes bedrock especially near its base in the area east of Erie (Figure 6).

The surface of the lake plain is extremely flat except for abrupt rises up onto former beaches created by higher levels of the lake (Figure 7). Behind the rises, to the south, a higher, flat level continues. It was on the flat surface of the lake plain, and especially on the rises, that the early east-west highway and rail network was laid out. In southern areas of the lake plain, the surface becomes hummocky and irregular because a band of glacial deposits was dumped there which was never overrun by lake waters and consequently was never smoothed.

The soil of the lake plain is sandy near the lake; it is gravelly and sandy on the beach ridges. Locally soils are finer textured where they are developed on lake clays and silts or on till. Such areas exist in the westernmost lake plain, in eastern areas near the New York border and north of Harborcreek and Wesleyville, and in southern areas especially southwest of Erie to the Ohio border. Soils near the lake drain well but slowly. Along the southern border of the lake plain soils drain rapidly and are easily leached. Poorest drainage occurs in the areas of finer textured soils.

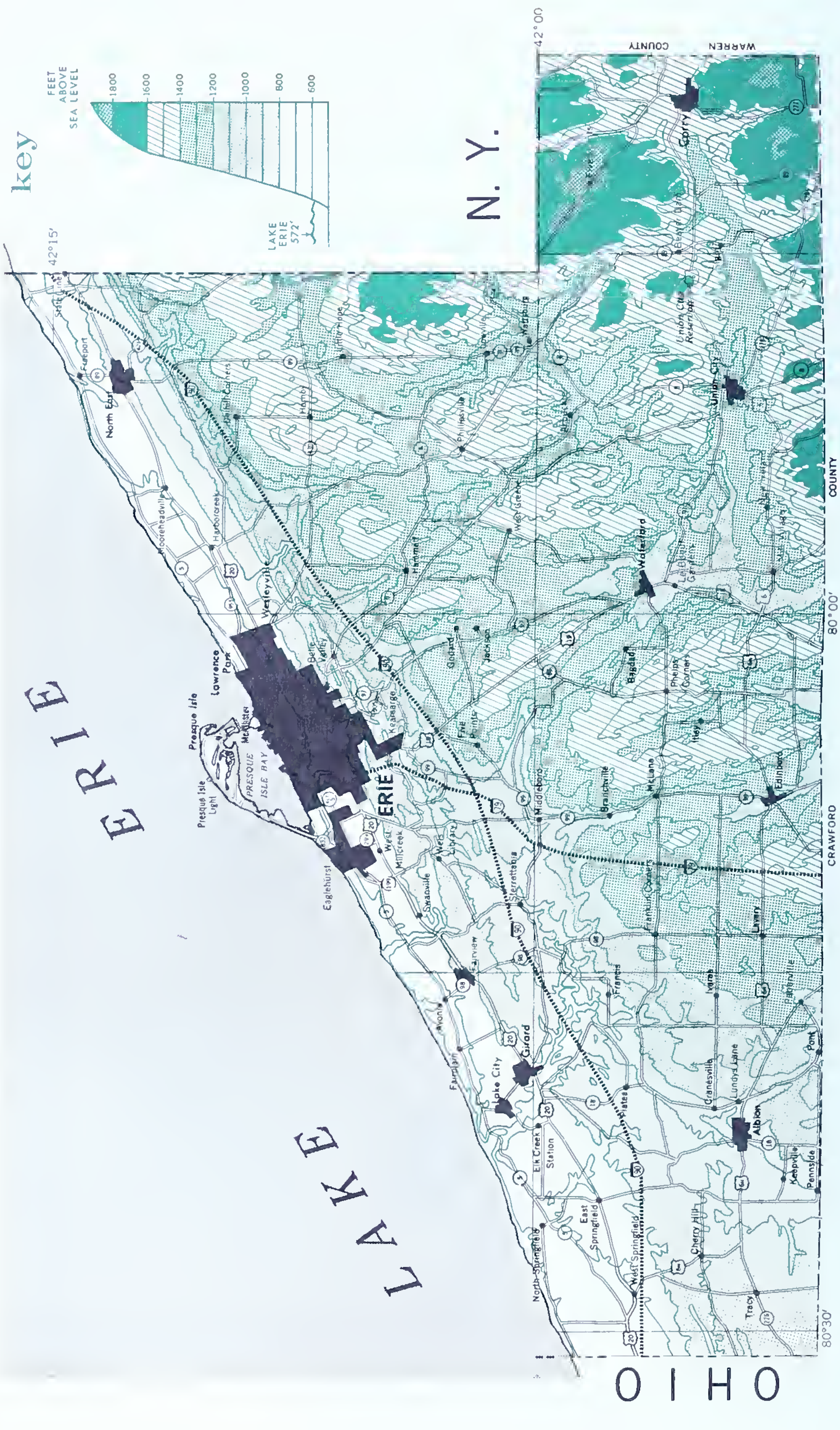


Figure 4. Map showing land surface elevations in Erie County.

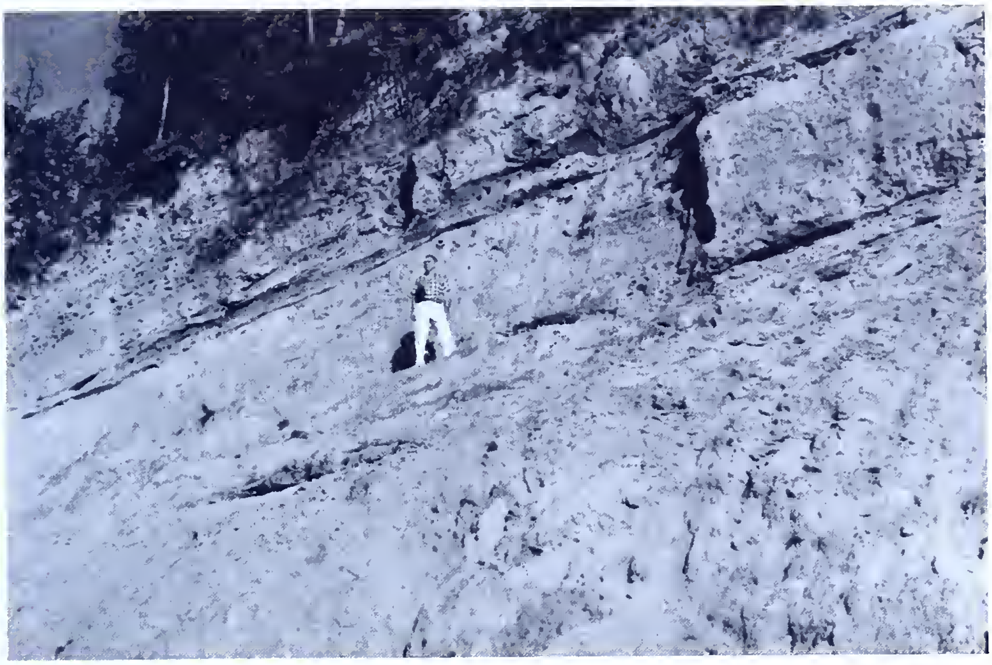


Figure 5. Glacial sediments exposed in the cliff along Lake Erie at Springfield Community Park. The man's feet rest upon blue clay.

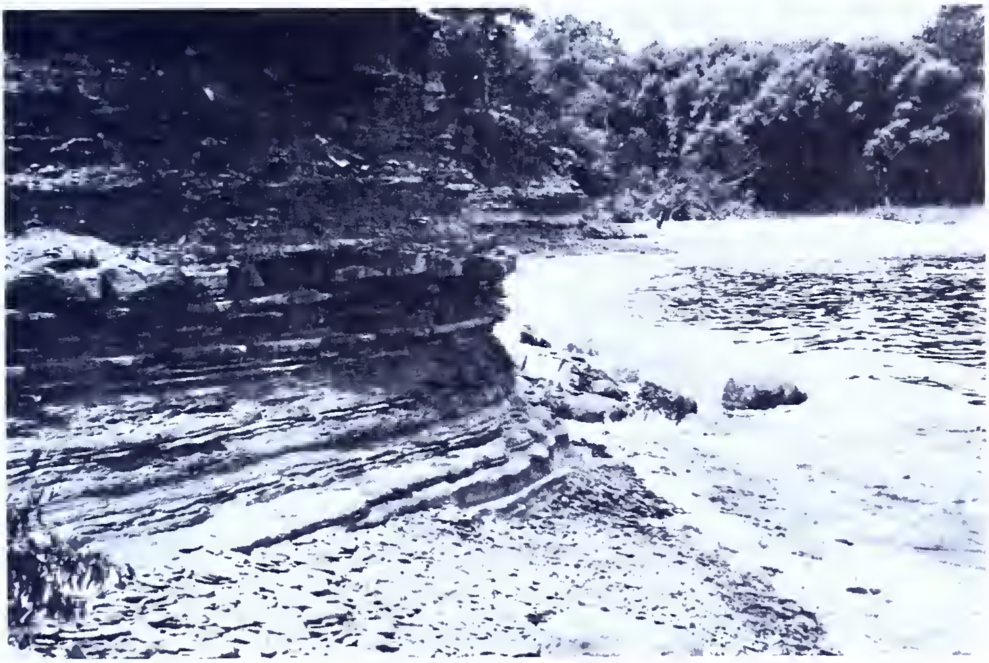


Figure 6. Bedrock exposures in the Lake Erie cliffs at Lawrence Park. Cliffs of shales interbedded with thin sandstones rise 35 feet above lake level.

Farming on the lake plain specializes in nursery stock, fruit crops, and early maturing vegetables. Nearly all the grapes grown in Pennsylvania come from the lake plain (Figure 8). The county also ranks high in the production of sour cherries. Nurseries specialize in commercial evergreen shrubbery. Of the 305 fruit farms and 70 poultry farms in the county, all but a handful are found on the lake plain.

More than 75 percent of the county's people live on the lake plain, mostly residing in the city of Erie, in six boroughs, and in the first-class township of Lawrence Park.

Climate on the lake plain is influenced markedly by the nearness of Lake Erie and differs from that of the upland. Temperature and precipitation measurements from records gathered at the Port Erie Airport are compared in Table 1 with records from Corry on the upland plateau. The control upon temperatures of the warm lake water in the fall and cool lake water in the spring are particularly evident in maximum temperatures and in snowfall amounts. Also affected greatly are the dates for first and last killing frost.

Water supply for municipalities and industries comes largely from Lake Erie or from surface streams. Only a few industries and the boroughs of Girard, Fairview, and Lake City derive much water from underground sources. Most ground water is obtained from glacial materials above the bedrock. The bedrock is not only a poor yielder of water, but waters except at shallow depths are likely to be saline. Many homes obtain water from shallow drilled or dug wells.

Streams flow across the lake plain in steep-walled valleys cut into glacial or lake deposits; streambeds are on bedrock.

The Escarpment Slope

Bordering the lake plain at an elevation of 800 feet and extending upward steeply to an elevation of about 1000 feet is the escarpment slope (Figure 4). The slope is best developed at its eastern end where its base is two miles south of the lake and it rises 400 feet in less than a mile. Westward across the county, the slope gradually moves back from the lake so that its base is five miles from the lake at the Ohio line. In addition, the steepness of the slope decreases westward so that it becomes difficult to define its southern border in the area in and around Albion. Most likely, the escarpment in this area is actually represented by two smaller escarpments, one marked by a solid line on Figure 4, the second marked by a dashed line. The area intervening between these two lines has a character intermediate in elevation and surface features between lake plain and upland escarpment. The soil types of this intervening area occur only rarely elsewhere in Erie County.

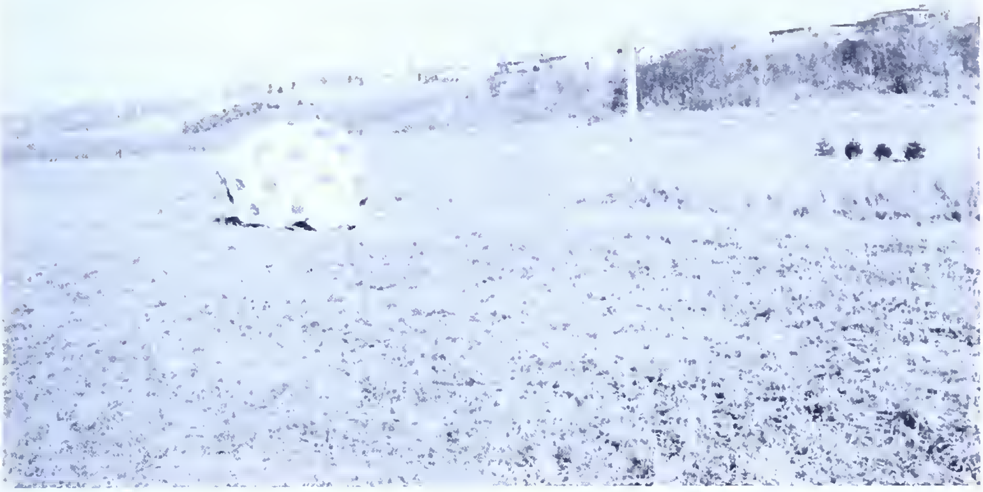


Figure 7. Beach ridge of ancient Lake Whittlesey at Fairview Borough. Houses atop beach ridge overlook flat lake beds which were deposited on lake floor. Boulder in foreground is of andesite, a rock foreign to Erie County which must have come either from Canada or the Adirondacks. The coat of yellow paint with purple polk-a-dots upon the boulder attests to an Erie Countian's sense of humor.

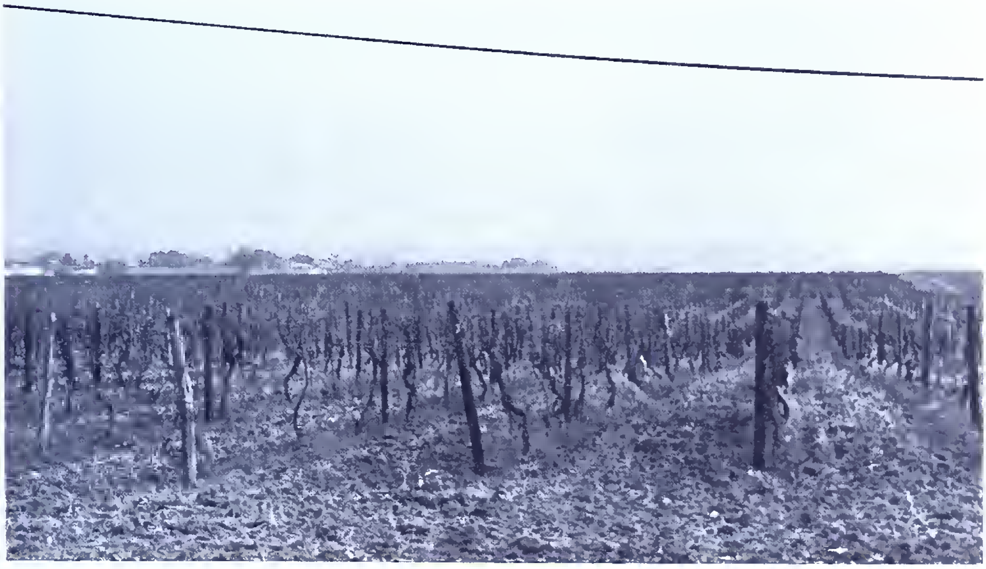


Figure 8. Vineyards blanket the Lake Plain, especially east of Erie and into New York State. The Escarpment Slope is seen in the background. A tree-topped rise behind the vineyards is a beach ridge.

The escarpment slope probably owes much of its existence to the resistant bedding of shales and flaggy sandstones that underlie it. This does not mean that this formation is the only controlling factor in the development of the slope; as it is followed into New York State other formations are found underlying most of it. At the base of the slope in Erie County are found soft shales which also underlie most of the lake plain.

There are no major settlements on the upland slope although many homes are built along the narrow roadways that follow the ridge. This location gives the homeowner an excellent view of the lake while affording him also the disadvantage of direct exposure to the winter winds that flow across the lake from the northwest.

The fruit farms of the lake plain are extended for a short distance up the slope. The crop here has shifted from the sensitive peach and grape to the hardier apple and cherry. Much of the slope is timbered.

Northward-flowing streams such as Elk Creek and Walnut Creek have cut dramatic deep valleys through the escarpment slope and deep into bedrock (Figure 9). Wintergreen Gorge, south of Wesleyville, is a favorite spot of hikers and climbers who are challenged by its hundred-foot walls.

Ground-water supplies of the slope are generally adequate for domestic purposes, especially in western areas.

The Upland Plateau

The largest portion of the Erie County land surface lies in the upland plateau which is a continuation of the glaciated section of the Appalachian Plateaus province (Figure 1). The upland surface is relatively smooth and gently rolling (Figure 10) and rises in elevation from 1000 feet along the escarpment slope to slightly above 1900 feet in southeast Erie County. The smooth, rolling uplands are interrupted by an incised drainage network which is flowing in broad, 100- to 300-foot-deep valleys with rather steep walls and commonly with flat floors. Valley intersections are commonly sites of very hummocky ground as are some valley bottoms.

The topography is that of an eroded plateau which has been in part masked and modified by glacial erosion and deposition. The relief which exists in the upland plateau is less than that which existed prior to glaciation, for the major action of the ice invasion appears to have been one of filling of valleys rather than of cutting them. Records show that filling locally has decreased relief as much as 300 feet. The somewhat irregular pattern of valleys, some of which contain streams obviously too small for the valley size, can be attributed to the interruption of drainage by glaciation.

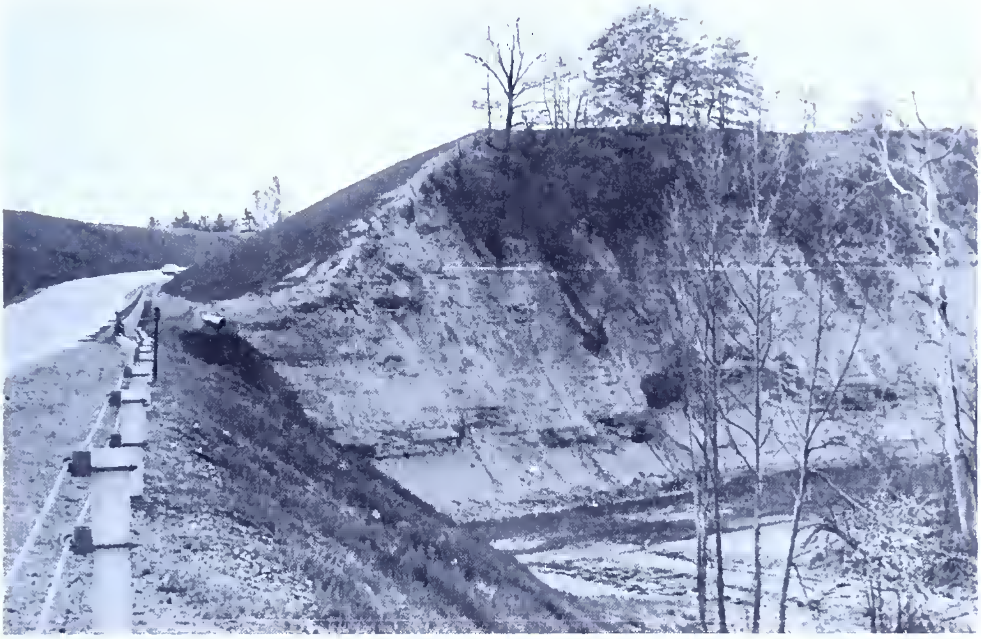


Figure 9. Bedrock exposed in the steep walls of Elk Creek viewed from nearby Route 98.

Figure 10. View of Upland Plateau near Franklin Center. Farming is undertaken next to wooded lots which are frequently swampy.

Much of the upland surfaces contain poorly drained areas — sites of former swamps. Soils on the uplands nearly always are developed on glacial till; they are moderately to very poorly drained, acidic and generally high in nutrients.

Valley bottoms contain soils developed on sands and gravels; valley walls have well-drained soils developed either on till or on sands and gravels. Undrained depressions, swamps, and lakes of various sizes occur frequently in the valley bottoms (Figure 11). These have a glacial origin in nearly all cases.

Well-drained soils in the upland plateau are well suited to late maturing vegetables, cabbage, and cauliflower, and especially in the valley bottoms, to root crops and potatoes.

Dairy farming predominates in the poorly drained upland and valley bottom areas. Of the 760 dairy farms in the county in 1961, almost all were in the upland plateau. Much land is kept in timber, a cash crop which requires little maintenance (Figure 12).

Northeast of Waterford the land surface is covered with drumlins — streamlined spoon-shaped hills left by the glaciers. Farming is difficult to impossible in this area and much of the land is in pasture.

A drainage divide traverses the upland plateau from northeast to southwest as shown on Figure 30. Streams draining north from the divide generally flow on bedrock; those draining south flow in valleys filled with glacial materials, usually sand and gravel outwash or lake silts and clays (Figures 13 and 14).

The precipitation and temperature in the upland plateau are typified by those measured at Corry and shown in Table 1. Similar rainfall records have been obtained also at Edinboro. The number of frost-free growing days on the upland is 121, small when compared to the 193 days of the lake plain.

Table 1. — Climatic data at Erie and Corry*

Climatic factor	*Port Erie Airport Lake plain*	*Corry Upland plateau*
Average annual temperature	49.3° F.	47.8° F.
Highest temperature recorded	98.0° F.	110.0° F.
Lowest temperature recorded	— 19.0° F.	– 30.0° F.
Average annual precipitation	37.28″	43.68″
Precipitation in driest year	23.84″	32.09″
Precipitation in wettest year	54.83″	51.57″
Average annual snowfall	55.50″	91.40″
First killing frost (Approx.)	Oct. 20	Sept. 27
Last killing frost (Approx.)	April 27	May 23

° Data from Soil Survey of Erie County, U.S. Dept. Agriculture, Ser. 1957, no. 9, December 1960.

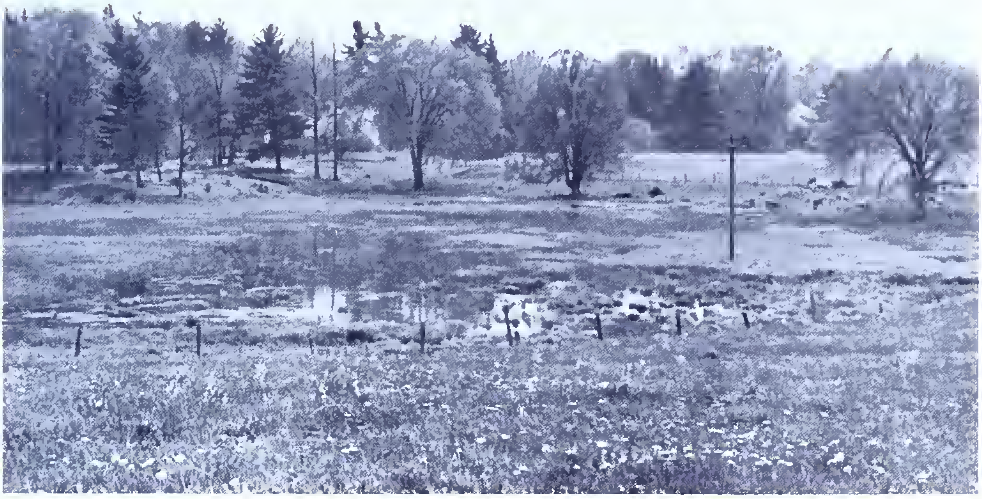


Figure 11. Swamp near Union City which formed by the filling in of a kettle lake.

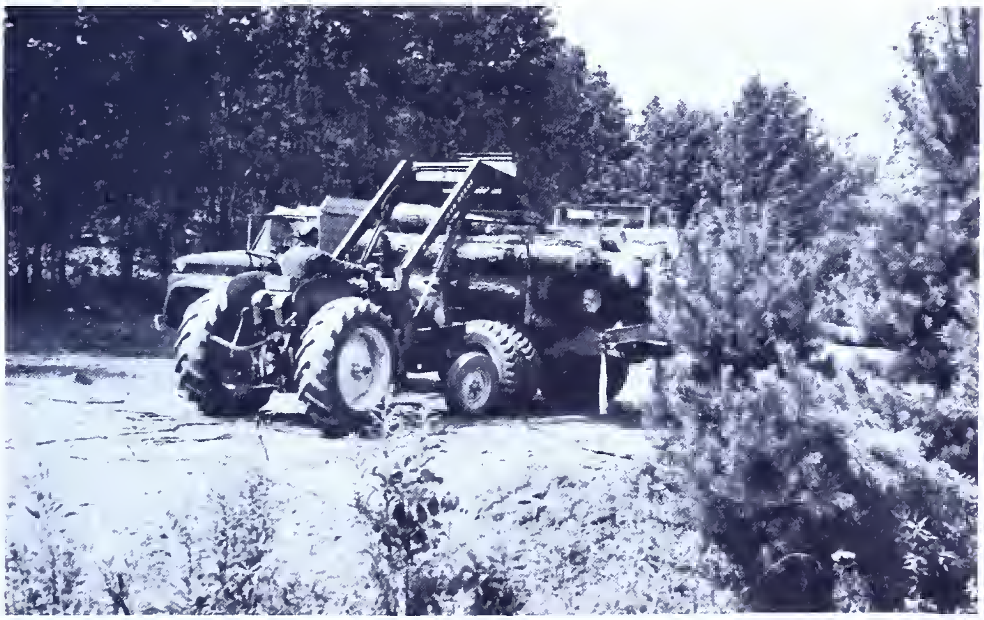


Figure 12. Harvesting a timber crop of beech, poplar, and maple. This operation near Lavery employs four men who produce 2500 board feet a day during the summer months.

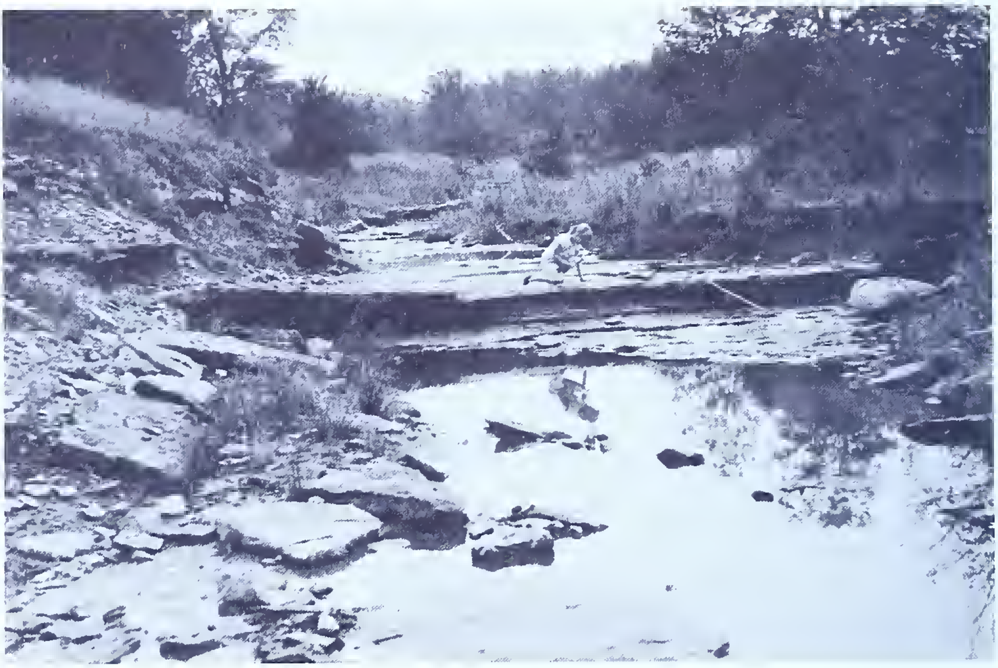


Figure 13. Streams that flow northward frequently flow on bedrock. Pictured here is Goodban Run in August. Rock is sandstone of the Cattaraugus Formation.

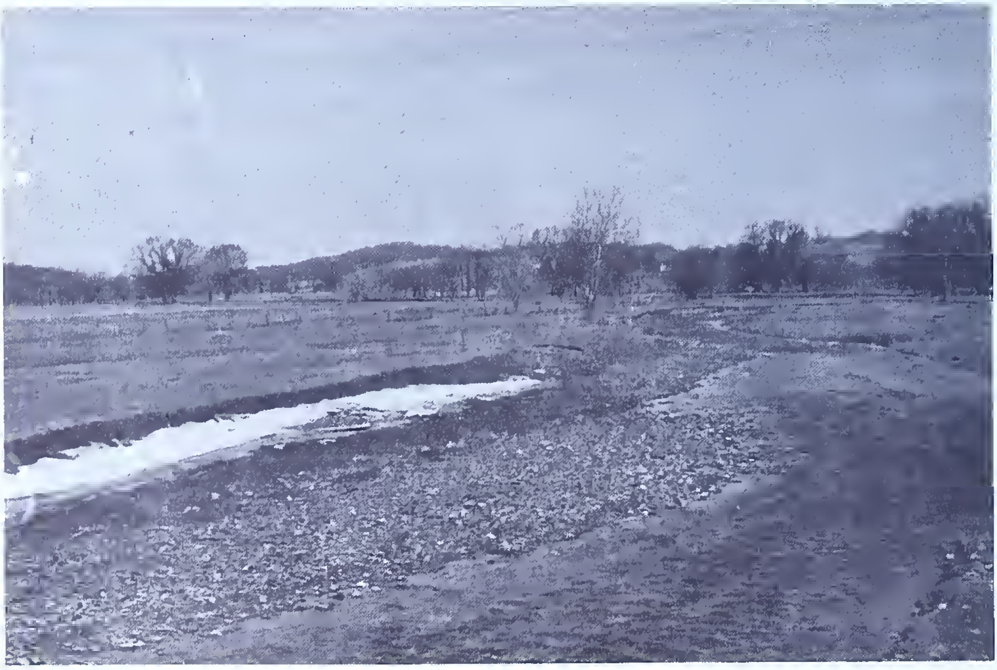


Figure 14. South-flowing stream running in flat-floored valley formed on glacial fill. Shown is Little Conneautee Creek in April.

Ground-water supplies on the uplands and valley walls are generally adequate for domestic use. Many wells derive water from glacial materials or at the contact between bedrock and overlying glacial materials. Sands and gravels in the valley bottoms are the best sources of water for industrial or municipal use.

Major settlements of the upland plateau include the city of Corry with a population of 7,744 and the boroughs of Albion, Edinboro, Waterford, Wattsburg, and Union City which have a total population of 7,240. An additional 20,000 people (estimated) living in the upland plateau area occupy villages smaller than 450 population or live in individual homesteads.

A comparison among the lake plain, escarpment slope, and upland plateau areas is given in Table 2. A summary of the land use in Erie County is given in Figure 15.

TRANSPORTATION

Erie County is traversed by three major east-west highways and two major north-south highways (Figure 16). Five major railroad companies operate within the county along with thirty-one large interstate motor freight haulers. There are three passenger airlines and five air freight lines operating out of the Port Erie Airport. Bus transportation is provided locally and nationally. Six freight forwarding companies operate within the city of Erie. The Port of Erie offers the finest in dock facilities to large transport ships. It is small wonder that the Rand McNally Regional Atlas lists Erie under its Principal Cities of the World.

Table 2.

Comparison of Some Basic Elements of the Physiographic Divisions

Item	*Plain*	*Slope*	*Plateau*
1. Approximate elevation above sea level	572-800 ft.	800-1000 ft.	1000-1900 ft.
2. Land surface	flat lying, well drained	steep in east, gentle in west some spots poorly drained	flat lying knobby in east, undulations in west, poorly drained in spots
3. Average annual precipitation	38 inches	38-40 inches	44 inches
4. Farm products	fruit, poultry	some fruit	dairy products
5. Average frost-free days	193 days	180-190 days	121-140 days

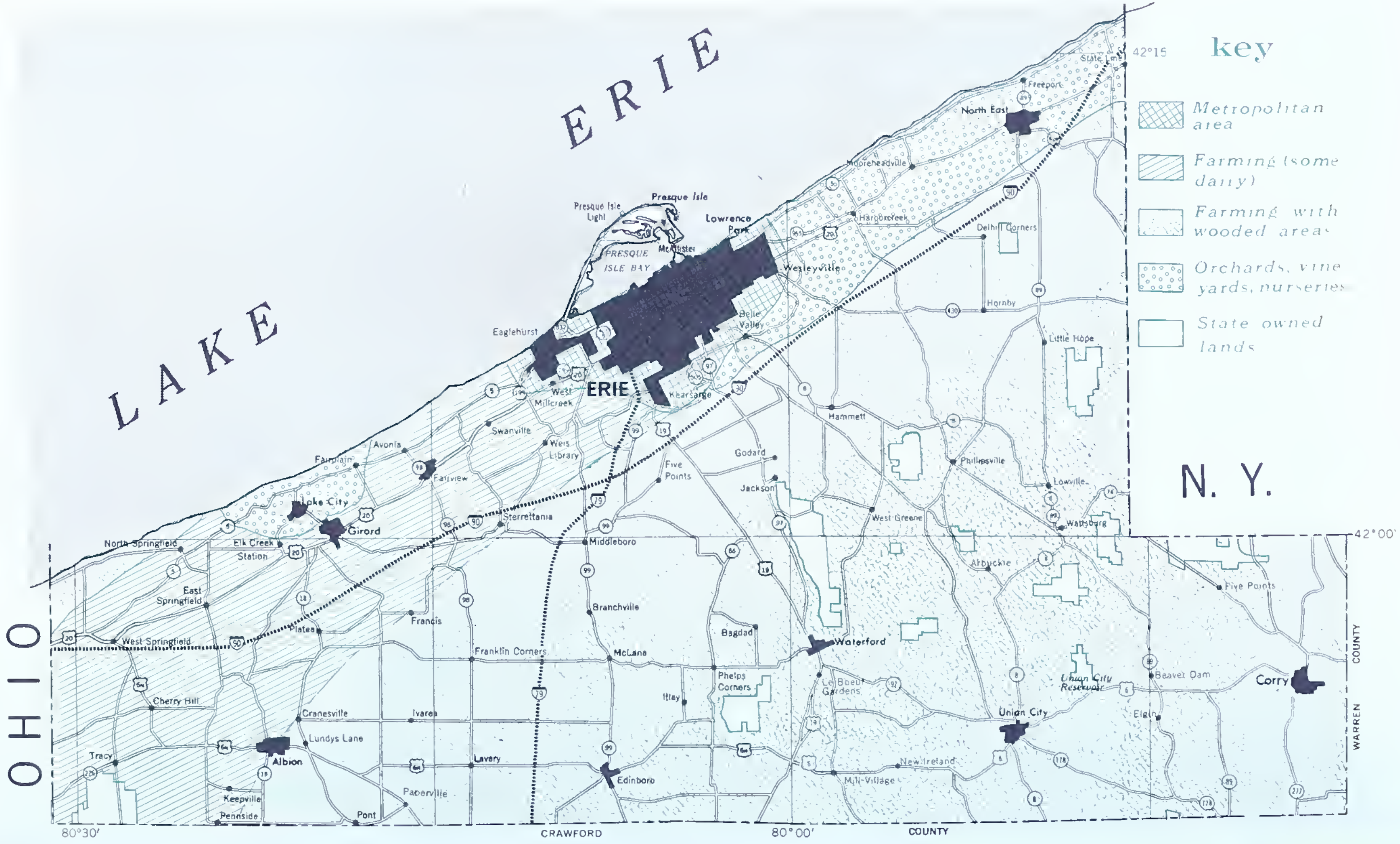


Figure 15. Land use map of Erie County.

PORT OF ERIE

Erie Harbor is a land-locked body of water, two miles wide and five miles long. Any ship that can travel the St. Lawrence Seaway can enter the harbor at Erie. Over three million tons of products pass through the port facilities in one year. The main products imported are pig iron, woodpulp, newsprint, rubber, tin, tapioca, flour, road salt, and plywood. In exchange for these Erie sends out oil, oil products, lumber, machinery, and steel products. Ships come to Erie from ports of all continents of the world except Antarctica.

The Port provides excellent facilities to the hinterland with direct rail and truck loading. Erie is one of twelve cities with port facilities on Lake Erie. It is an active member of the Council of Lake Erie Ports which was organized in 1955 as an agency to promote the development of foreign trade that was to result from the new development of the St. Lawrence Seaway. The Port usually opens in April and closes around November depending upon the condition of the Great Lakes.

INDUSTRY

The largest single employer in Erie County is the General Electric Company located at Lawrence Park. Here 6,000 employees produce locomotive motors and generators. The largest combined labor force, however, is engaged in iron and steel processing with eight large companies represented. Combined electrical products employ the second largest number of workers, followed in numbers by the plastic- and rubber-products industries. The fourth major industry, located in the Erie area, is that of writing and printing papers and the fifth is toy manufacturing. Other industrial products of international and national importance are the products of the American Sterilizer Company which manufactures hospital equipment and the Eriez Manufacturing Company which produces magnets. In 1958 the total value added by manufacture was $308,019,000 for Erie County.

Products from Erie County are transported to every corner of the world. Eriez magnets are exported to 62 foreign countries, General Electric motors go to 51 different countries, and laboratory equipment from Autoclave Engineers reaches 22 foreign countries.

POWER SOURCES

Electricity is supplied to the area by facilities in the city of Erie which are tied into power supplies from the Niagara Falls region. Erie electricity is produced from coal while electricity from Niagara Falls is hydroelectric. Electricity is available for home and industrial use in unlimited quantity in Erie County.

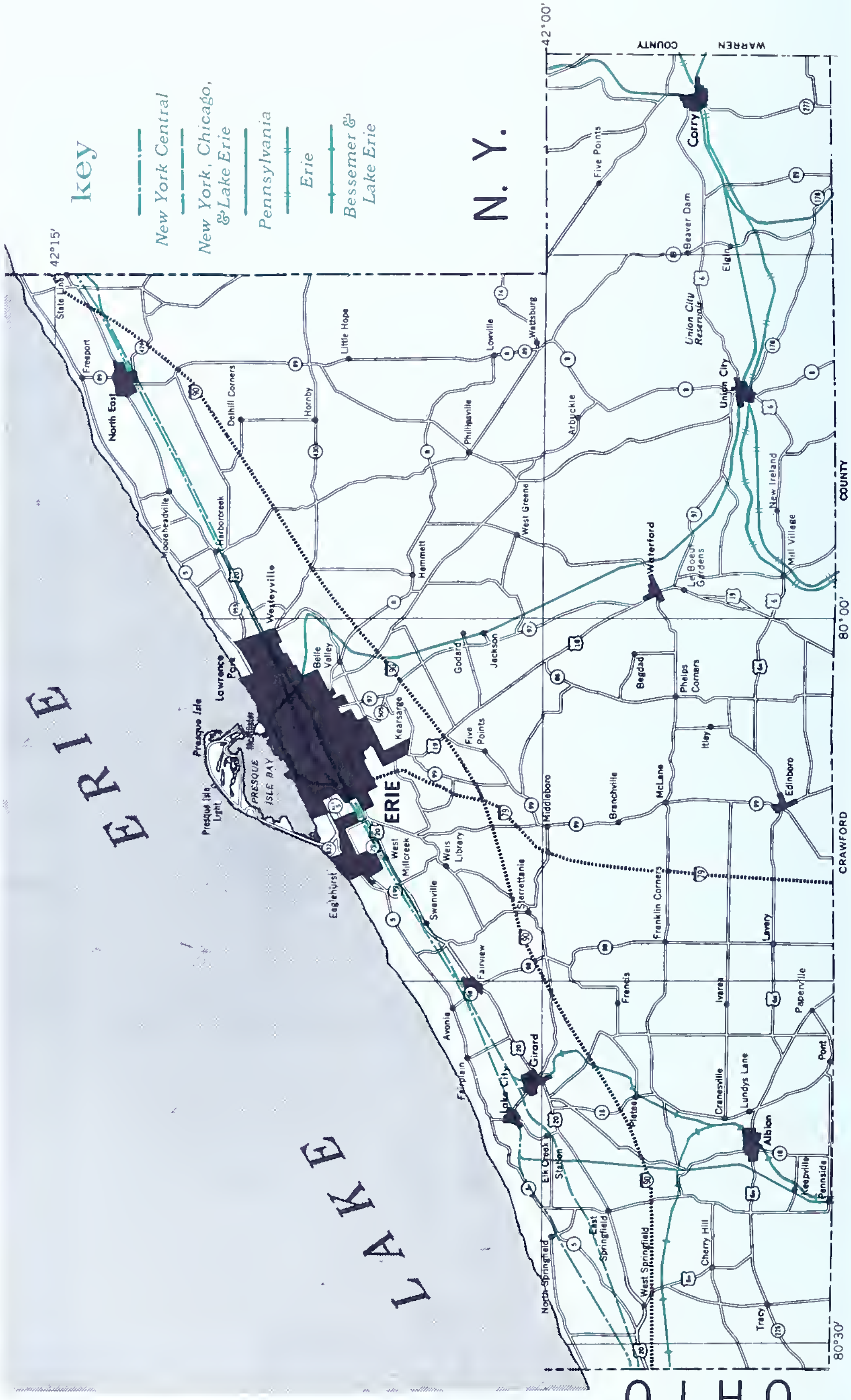


Figure 16. Map of highway and railroad network in Erie County.

Natural gas is delivered to the area from Tennessee and southwestern United States. These areas supply about 90 percent of local needs with the remaining 10 percent derived from local wells and manufactured sources. Many commercial producing wells in the county are tied into the imported pipeline sources. A number of home-owned wells are located along the lake in an east-west line. Most of these derive gas from about 2000 feet below the surface. The gas is used mostly for cooking since pressures are usually not adequate to furnish fuel for heating.

Fuel oils are available in bulk quantity from large commercial gasoline companies. The largest operating company in 1961 was the Atlantic Refining Company which sold fuel oil mostly to homes.

Coal is shipped in from the Pittsburgh region by truck and rail. Ships also deliver coal from other ports on the Great Lakes. Coal is used mostly in the steel and forge industries with limited amounts being used for home heating. Area home owners are rapidly switching from coal and fuel oil heating to gas and electric.

THE GEOLOGY OF ERIE COUNTY

THE BEDROCK COLUMN OF ERIE COUNTY

Erie County lies upon a foundation of between 6000 and 7500 feet of nearly flat-lying lithified rock layers. Beneath these rock layers is a complex unit of once-molten crystalline igneous rocks called the "basement." The basement rocks were formed more than 600 million years ago in a sequence of events which is essentially unknown in the area of Erie County. Only one well in Erie County has ever gone deep enough to sample the basement rocks and the nearest exposures of these rocks are in Canada.

It is known that erosion following formation of the basement rocks was sufficient to wear the land surface down to a relatively smooth plain. About 550 million years ago, this landscape was submerged beneath a broad inland sea which covered most of Pennsylvania and New York and nearly all of central United States. Muds, sands, and lime muds were carried into the sea and were deposited as layers on the sea floor. Deposition continued for nearly 350 million years during which time Erie County remained almost continually under the sea. For only a few brief periods sea level was lowered enough to bring the land out of the water and allow the removal by erosion of some of the previously deposited layers.

During this long period of time, which covered all the geologic time periods from Cambrian to Permian (see Figure 17), layer after layer of

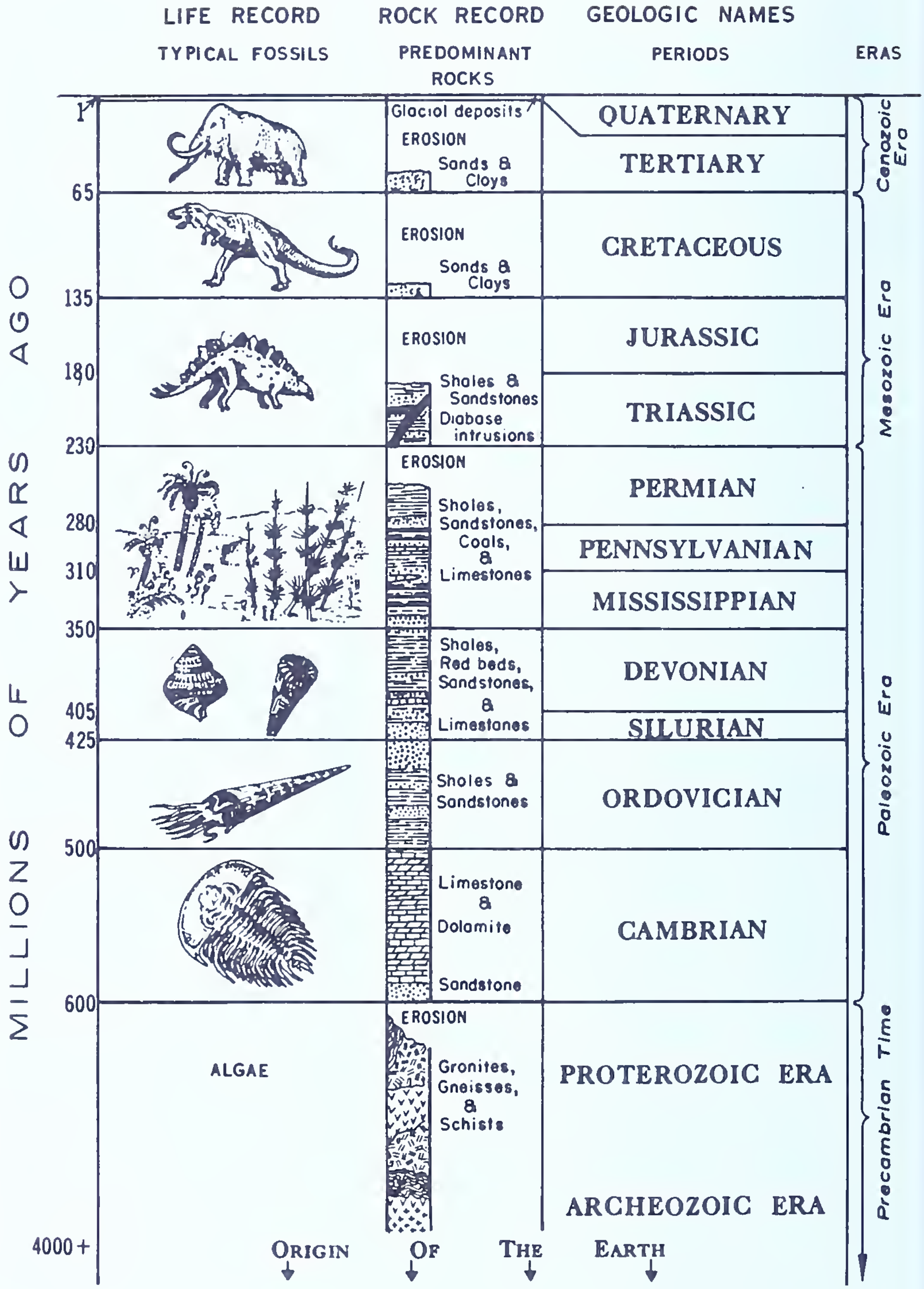


Figure 17. Geologic time scale.

sediment was deposited in the Erie County area until nearly 10,000 feet of sedimentary rock had been formed. Then, about 230 million years ago toward the end of the Permian Period, crustal movements lifted the land high above sea level and deposition ceased. Erosion began gnawing away at the top of the thick sedimentary blanket so that today, 230 million years later nearly 2000 feet of rock has been entirely removed from the county and streams have cut into and partially removed another 1500 feet. Over 6000 feet of rock lie concealed from view beneath the surface.

Rocks Beneath the Surface

The 6000 or more feet of rock which lie beneath Erie County's surface can be seen only as cuttings or core samples taken from drilled wells. One such well, the only well in Erie County to reach basement rocks, was drilled in the city of Erie. The record of the rocks encountered is shown in Figure 18. As one moves north from Erie County into New York State and Canada, erosion has cut deeper and deeper into the rock column so that the subsurface rocks of Erie County are gradually exposed. The names given to the rock layers have generally been applied in the areas where the layers are exposed. Accordingly, the names applied to Erie's subsurface rocks (see Figure 18) have come from local geographic names in New York, Canada, Michigan, and as far away as Wisconsin.

Going south from Erie, the rock layers are buried to successively greater depths. Since the land rises as you move south, and since the rock layers have a slight dip to the south, the depth to which a well must be drilled to reach basement increases. The thickest sequence of rocks in Erie County would be found south of Corry where land elevation is the highest. A well at that location would penetrate about 1500 feet of rocks before it reached the rock layer exposed at the top of the well in Erie. That same rock layer at Pittsburgh lies nearly 4000 feet beneath the surface.

Rocks below the surface of Erie County comprise limestones, dolomites, shales, salt beds, and some sandstones (Figure 18). Limestone and dolomites are particularly abundant in the first 2000 feet of rock deposited above the basement crystallines; they are of Upper Cambrian and Lower and Middle Ordovician age. These are chemically deposited rocks in many cases and suggest that the sea at that time was rather calm and that Erie County was far removed from an exposed landmass. Sediments were coming into the sea from landmasses to the east, but only the finest size fractions were able to reach Erie County. During Late Cambrian and perhaps some of Early Ordovician time, conditions

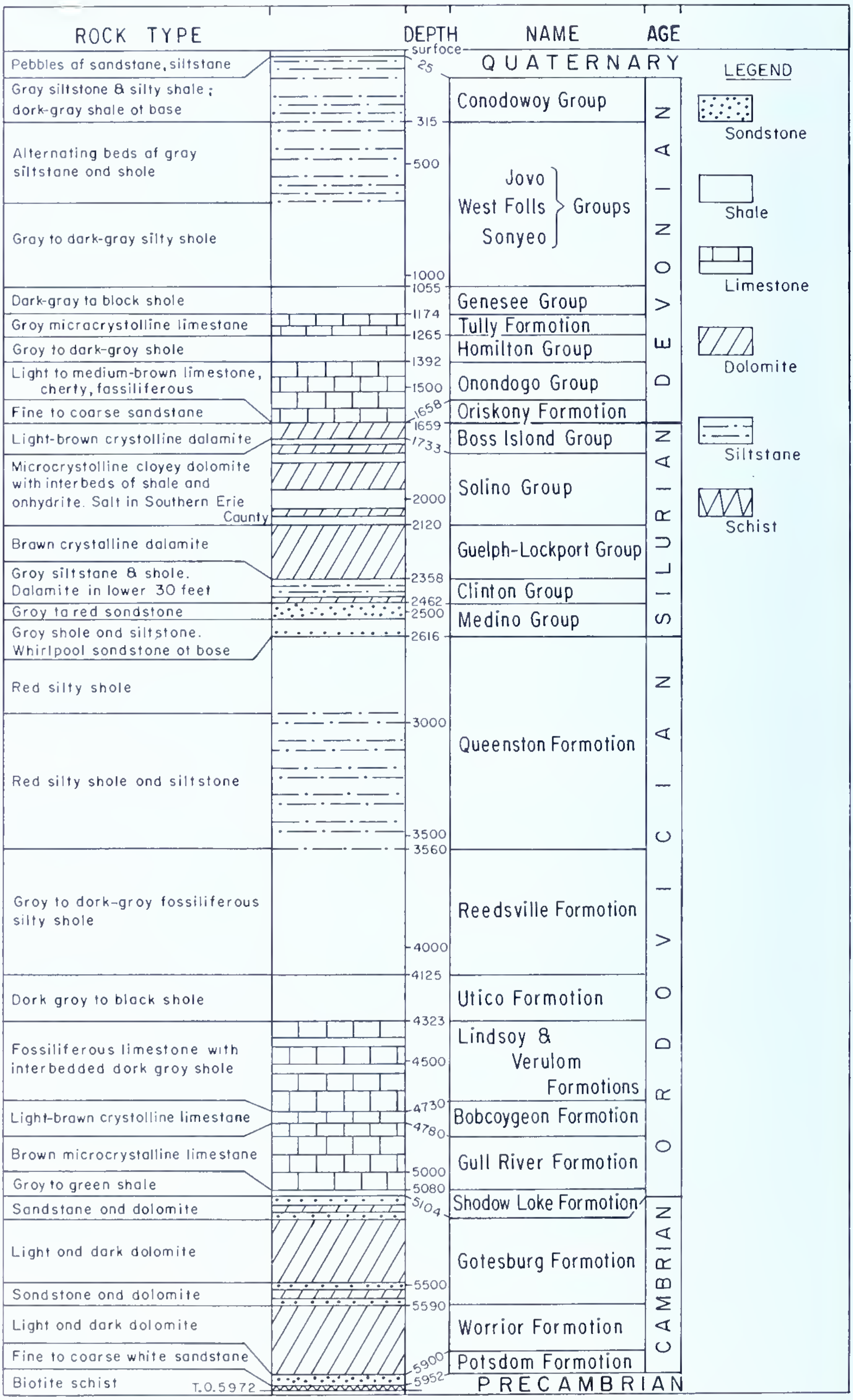


Figure 18. Bedrock column beneath the surface in Erie County at Erie. If one were to drill a well at Erie, these are the rocks which would be penetrated.

changed and sediments coming into the area of northwestern Pennsylvania were from the north. Several uplifts occurred during the early Ordovician time so that erosion removed some of the Upper Cambrian rocks.

Toward the end of the Middle Ordovician time, crustal movements to the east of Erie County caused deposition of muds, silts and sands to begin in the east. At the same time, deposition of clastic materials such as clays and fine silts progressed into the Erie County area so that a thick sequence of dark shales was formed, followed by silty shales and siltstones. Early Silurian time saw coarser grained sediments — silts and sands — deposited from eastern sources as the sea alternately encroached upon and retreated from northwestern Pennsylvania. As the Clinton beds were deposited, the sea moved into the area and remained there for the rest of Ordovician time. Sediments thereafter were characteristic stable sea deposits, i.e. limestones, dolomites, claystones, and salt beds of the Salina Group. The beds of salt indicated that the seas were at times restricted so that evaporation could cause concentration and subsequent deposition of salt. It is these salts which are mined in Michigan and New York.

Deposition of limestones and dolomites continued after the period of salt formation into the Devonian and four formations were deposited as shown in areas outside of Erie County. In Erie County, deposition of the four units was followed by uplift and erosion which removed all but the Bass Island Formation, the lowest of the four units. Deposition resumed as sea level rose and a quartzose sandstone known as the Oriskany sandstone was laid down as a thin but continuous layer upon the erosion surface. The Oriskany sand is well known throughout western Pennsylvania for it is the most important oil-bearing rock in the state.

Limestone deposition followed the Oriskany sand indicating a stable marine environment. The buildup of a large delta known as the Catskill delta in eastern Pennsylvania and New York brought large quantities of rock debris into the sea. Clays and fine silts were carried westward into Erie County and for the remainder of Devonian time, a thick section of shale was built up. The shale is interrupted periodically by a thin limestone or sandstone suggesting times of greater or lesser influx of clastic materials, or perhaps occasional shifts in water depth.

Rocks Exposed at the Surface

The oldest rocks exposed at the surface are Upper Devonian. The history of the formation of Erie County's rocks continues without break from that presented above for the subsurface. Shales formed up to and past the end of the Upper Devonian, but sandstones become more numerous in the Mississippian section suggesting again a tendency toward shallower waters. Toward the end of Mississippian time, land rose and was again subjected to a long period of erosion. Upper Mississippian rocks were removed and no further deposition occurred until well into the Pennsylvanian Period. Sea levels again rose and the land surface dropped to or just below sea level. Only a few feet of Pennsylvanian age sandstone remains in Erie County, all else having been eroded away. But from adjacent areas we can surmise that Erie County received sediments throughout most of Pennsylvanian time and perhaps into Permian time. Land surface during most of this time was probably frequently above and below water level. Meandering shorelines probably moved back and forth across the land surface. The buildup of extensive swamps occurred on many occasions throughout the Pennsylvanian and after compaction has led to the many coal beds for which Pennsylvania is noted. Coal might have been one of Erie County's important resources except for the fact that it was all removed by erosion.

The time following the early Permian saw the elevation of Erie County to heights well above sea level where it remains today. A stream system set up upon the surface of the Permian and Pennsylvanian deposits began immediately to eat into the sandstones and shales. These were carried and redeposited in a new sea to form new rocks. The present drainage system in Erie County has evolved from that ancestral system which removed so much of the rock layers; it is still going about the business of eating away the rocks today.

The surface rocks are of perhaps more interest to the layman than are the subsurface rocks because they can be viewed directly and are the sources of fossils and minerals for the collector. The distribution of rock layers at the surface in Erie County is shown on a geologic map (Figure 19). Although bedrock underlies all of Erie County, it is not often exposed. A thick cover of glacial deposits conceals the bedrock over much of the county. Best exposures of the bedrock occur along the Lake Erie shore, along the walls of deep-cut creeks flowing down across the escarpment and the lake plain, and along artificial cuts made for quarries, highways, and buildings.

The oldest exposed rocks in Erie County belong to the Upper Devonian *Canadaway Formation* (Figure 20) and lie in a band along Lake Erie from the New York border nearly to the Ohio border. The beds dip slightly to the west along the lake so that the unit is thinning continually toward the west. Shales of this unit reach an exposed thickness in New York of 1400 feet, but their greatest exposed thickness in Erie County is 475 feet along the New York State border.

The Canadaway beds, called locally the Northeast Shale, consist of an alternating series of gray shale layers and thin layers of fine-grained

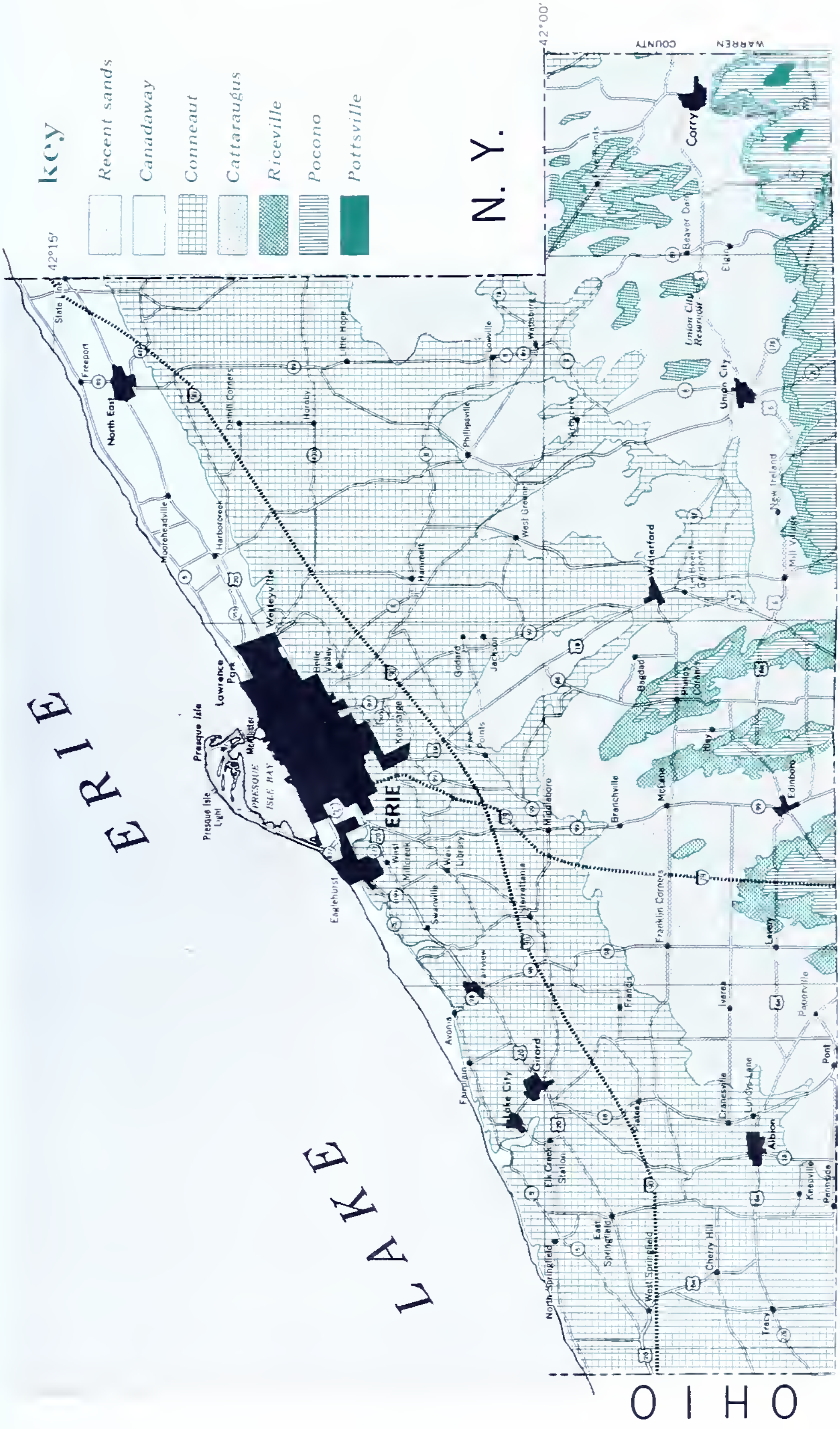


Figure 19. Geologic map of Erie County. Map shows bedrock units which would be exposed if glacial materials were removed. Taken from Geologic Map of Pennsylvania; 1960.

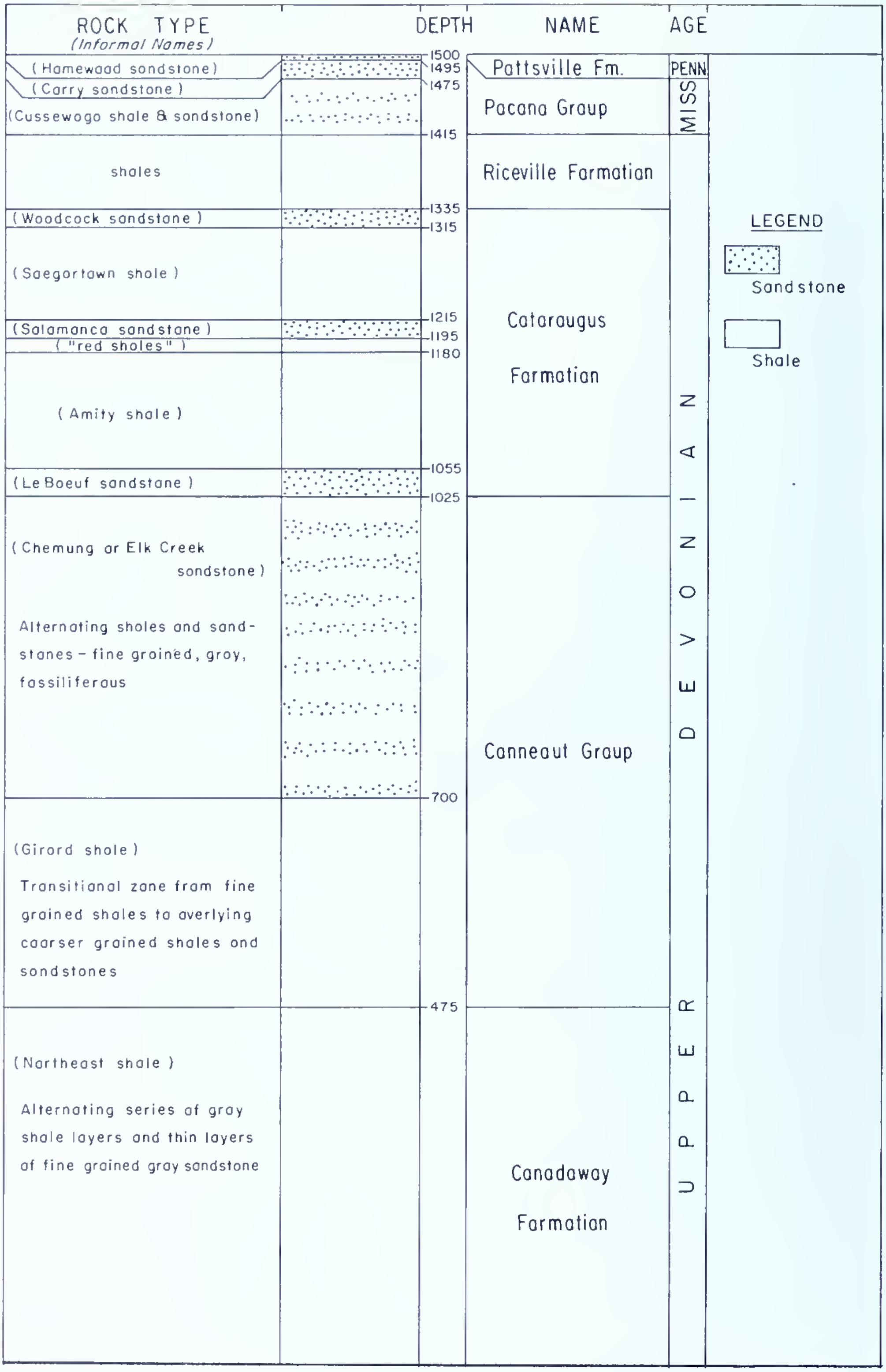


Figure 20. Bedrock column showing units exposed at the surface throughout Erie County.

gray sandstone (See Figure 21). Three of the sandstone layers were quarried east of the city of Erie at Fourmile Creek and Neelys Run and west of the city along Walnut Creek. The thickest layer quarried measured two feet. These sandstones and others develop into oil-bearing units in counties to the south and east of Erie County. Some gas has been produced from sands in the Canadaway Formation along the lake plain for use by individual home owners.

Scarcely any fossils exist in the shales and sandstones of the Canadaway. Markings on bed surfaces, called fucoids, are attributed to seaweed drag marks, animal trails, or water current scour marks, but their origin is not known with certainty. Structures, called cone-in-cone structures have been misidentified as fossils, but these features which resemble a stack of cones are thought to form when overlying sediments build up and exert pressure on lower beds. Their origin, like the origin of fucoids, is in doubt.

Overlying the Canadaway rocks is 550 feet of *Conneaut Group* shales and flaggy sandstones. The lower 50 to 225 feet of the group is called the Girard Shale. The thicker beds lie in the western part of the county. The Girard Shale serves as a transitional zone from fine-grained shales of the Canadaway to overlying coarser grained shales and sandstones of the upper Conneaut. The Girard Shale is ashen gray in color

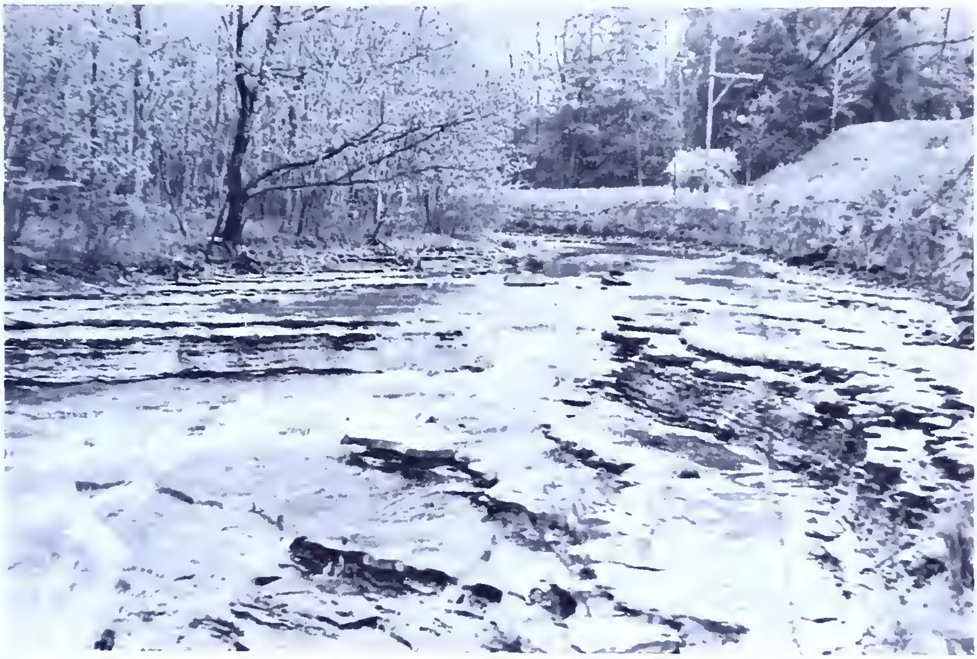


Figure 21. Canadaway beds exposed along Twelvemile Creek at Route 5.

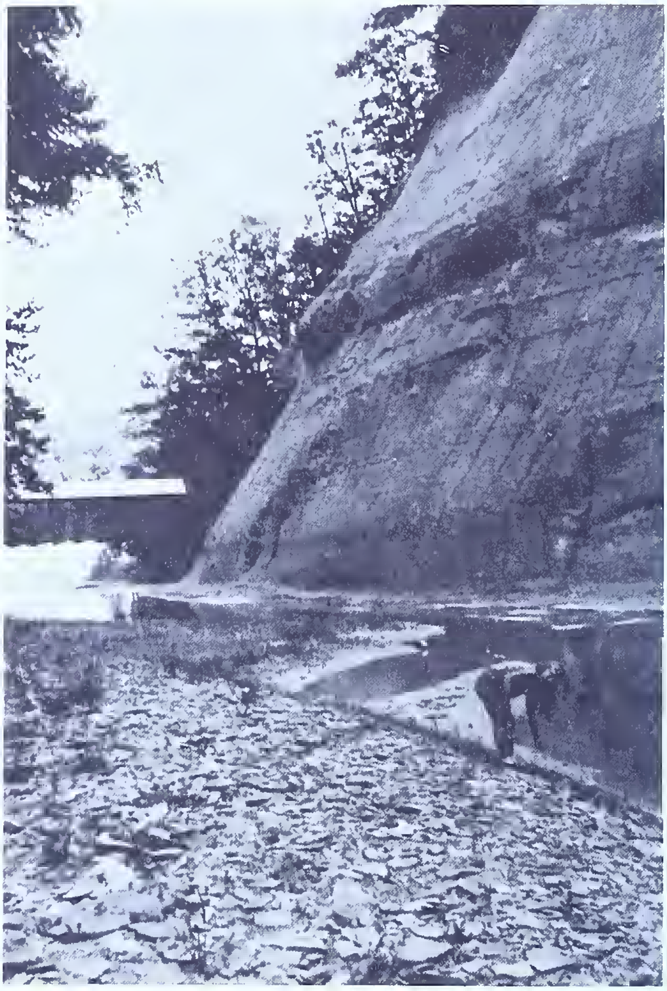


Figure 22. Lower Conneaut beds exposed along Elk Creek.

and has a uniform texture. It is exposed at lake level in the extreme northwest part of the county and underlies much of the lake plain and lower portions of the escarpment.

Fossils are generally lacking in the Girard, but some brachiopods of the genera *Cardiola, Spirifer,* and *Rhynchonella* may be found in this rock unit. Cone-in-cone structures, some measuring up to 3 inches at the base, may be found in the Girard shales.

The Girard Shale is separated from the upper Conneaut by a thin impure limestone layer. Above the limestone is 325 feet of alternating shales and sandstones which have been called collectively either the Chemung Formation or the Elk Creek sandstones. Neither name is used by geologists; the first name has been abandoned and the second was only used locally.

The upper Conneaut beds contain more and thicker sandstones than in units below, with some impure sandstone beds attaining a thickness of twenty feet. The best exposures of the shales and sandstones are along Le Boeuf Creek and the north-flowing tributaries of Elk Creek. It is the sandstones of the upper Conneaut which form waterfalls and rapids along the north-flowing streams crossing the escarpment. The sandstones are fine-grained and gray, but weather to a rich brown. They become oil-bearing in counties to the south.

The upper Conneaut beds, and especially the sandstones, are fossil bearing and fossils such as crinoid stems, brachiopods, and bryozoans may be collected, especially from the sandstones where they crop out in stream beds. Ripple marks attesting to the sea-bottom origin of the sandstones may be frequently seen on bed surfaces (Figure 23).

In the upland plateau many square miles of flat upland surfaces are underlain by sandstones and shales of the *Cattaraugus Formation,* the next rock unit above the Conneaut Group. The Cattaraugus beds are notably coarser than the beds below and contain thick, named sandstones (Figure 20). The Le Boeuf, Salamanca, and Woodcock sandstones have all been extensively quarried in many parts of the county. Near Waterford the Le Boeuf sandstone is 30 feet thick with one massive layer 4 feet thick. It is this layer which has been quarried in great amounts throughout southern Erie County. The stone is coarse grained

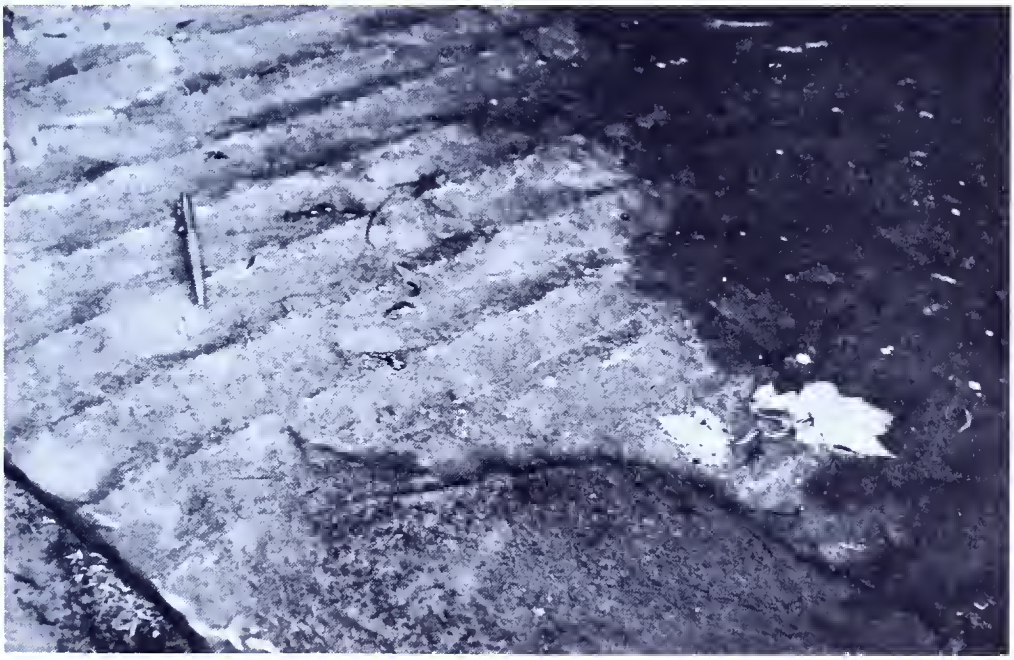


Figure 23. Fossil ripple marks on the surface of an upper Conneaut sandstone bed.

in contrast to the flaggy sandstones of the Conneaut. Locally the sandstone is pebble bearing. It has a grayish-white color which differs little from the color of the shales of the Cattaraugus. Along creek beds such as Goodban Run and Falk Run, exposures of the sandstone are weathered to a rusty color.

The shales separating the sandstones are about 100 feet thick and effectively seal one sandstone from another so that the sandstones have become reservoirs for oil accumulation. To the south, the sands of the Cattaraugus are known to drillers as the Venango sands, rocks known to yield oil even to the early drillers in Pennsylvania. The Le Boeuf sandstone is called the 3rd Venango, for example. In Erie County the Le Boeuf commonly has the smell of oil near Waterford, but does not yield it. Barns and houses which have foundations of local sandstone often show oil stains in the Waterford-Union City area.

Over 50 percent of the Cattaraugus beds originally deposited in Erie County have been removed by erosion. The *Riceville Shale,* the last of the Upper Devonian deposits, along with the shales and sandstones of the *Pocono Group* of Mississippian age, form most of the remaining higher upland areas. Beds of the 80-foot thick Riceville Shale, because of their nonresistant character, seldom form outcrops.

The Mississippian Pocono rocks comprise the Cussewago shales and sandstones and the Corry sandstone. While some of the Cussewago sandstones were quarried locally for flagstone, the Corry sandstone stands out as the most desirable stone for building purposes available in the county. The stone is a light-buff color and is composed of compact sand grains. The Corry measures about 20 feet in thickness and contains at its base about 13 inches of conglomerate containing pebbles which average ⅛ inch in diameter. Below the sandstone is a 5-foot impure limestone bed.

The Corry has not been extensively quarried because, unlike other sandstones in the county, it is seldom exposed along creek beds. Three quarries were opened into the stone south of Corry. The largest of these, called "Old Stone Quarry", has been back filled, but a creek-bed quarry in the Corry still exists along a northern unnamed tributary to Whitney Run.

Thin sandy shales belonging to the Mississippian Pocono Group continue for a variable number of feet above the Corry; rocks deposited during the Middle and Upper Mississippian were cut into and removed during early Pennsylvanian time. The erosion was irregular so that the Mississippian rocks remaining above the Corry are of irregular thickness in northwest Pennsylvania. In Erie County there are probably not more than several tens of feet of rock preserved.

Upon the old erosion surface rests the Homewood sandstone of the Pennsylvanian age Pottsville Group. All but a very minor amount of these Pottsville beds have been eroded from the county so that the Homewood sandstone exists on the tops of only two hills south of Corry (Figure 19). Its character is not known.

As noted earlier, deposition probably continued through Pennsylvanian time and into Permian time in the Erie County area. But at the end of the Permian, crustal movements were compressing and folding the rock strata in central and southern Pennsylvania and at the same time elevating the strata of Erie County. The erosion which followed removed all rocks above those described previously. It wasn't until the advent of glaciation during the Ice Age that Erie County again received sediments.

Ice Invades Erie County

About 1 million years ago the climate of the earth became generally cooler and a period of ice buildup in the colder latitudes began. Massive glaciers spread out from the areas of snow accumulation and invaded many regions of the earth. A vast continental ice sheet spread out over nearly all of Canada and moved south into northern portions of the United States. Readers unfamiliar with the story of the Ice Age and of glaciers are encouraged to read "Pennsylvania and the Ice Age", a free booklet issued by the Pa. Geol. Survey.

In the course of the next million years, known as the Ice Age, four major buildups of ice occurred, separated by periods of relative warmth during which time the ice completely or nearly disappeared. Within each major buildup, new glaciers formed and moved south out of Canada into the United States. These major stages of glaciation are named, from oldest to youngest, the Nebraskan, Kansan, Illinoian, and Wisconsin Stages (Figure 24).

Direct evidence that ice of the first three stages crossed Erie County has not been found in Erie County itself, but evidence has been found in counties to the south and east which shows that Illinoian ice and possibly Kansan ice must have crossed Erie County.

Deposits of these two advances may exist in Erie County, but such deposits would probably be buried by the deposits of later ice advances. Ice advances which moved as a tongue of ice down the length of the Erie basin spread out over Erie County during the Wisconsin Stage at least five times. These advances have been named, from oldest to youngest, the Titusville, Kent, Lavery, Hiram, and Ashtabula advances (Figures 24 and 25). The names are derived from geographic features in areas where the advance or the deposits of the advance were first studied and identified. The name Lavery comes from the small settlement of Lavery in south-central Erie County west of Edinboro.

NAME OF ADVANCE	GEOLOGIC FEATURE	TYPE OF SEDIMENT	SYMBOL
ASHTABULA	End moraine	Silt-rich till	░
HIRAM	End moraine	Clay-rich till	▓
	Ground moraine	Clay-rich till	▒
LAVERY	End moraine	Silt-rich till	▩
	Ground moraine	Silt-rich till	▦
KENT	End moraine	Till	■
	Recessional moraine	Till	▧
	Ground moraine	Till	▤
YOUNGER (with various advances)	Kames and outwash	Sand and gravel	□
	Lake deposits	Sand, silt, and clay	□

Figure 24. Chart of glacial advances and deposits in Erie County. Symbols refer to Figure 25.

Details of the ice advances in northwestern Pennsylvania are published elsewhere and will not be repeated in detail here for they are complex and require references to much evidence not available in Erie County. Details are given in Pa. Geological Survey Bulletin G-32 (see reference list at the end of this book). The deposits of the ice advances are shown in Figure 25.

Ice of the first Wisconsin glaciation, called the Titusville glaciation, moved into Erie County about 28,000 years ago, entirely covered the county and moved many miles to the south and east. This ice then melted away and left Erie County exposed to the elements. A long period of time elapsed during which the front of the Titusville ice retreated north into Canada. A soil formed on the deposits in Erie County. Then about 20,000 years ago or perhaps somewhat later, the Erie lobe of the great ice mass in Canada again invaded northwestern Pennsylvania and once more Erie County was entirely covered by ice of the Kent advance. Upon stagnation and melting of this ice sheet, the ice front by about 14,000 years ago had once again left Erie County and melted back into the basin of Lake Erie. Evidence to the north in Ontario shows that the ice front did not retreat out of the Erie basin. Presumably a large lake would have formed in the Erie basin in front of the glacier.

During the next 4000 years, the ice front made three minor readvances sufficient to carry it again into Erie County. The front edge of the ice during each of these advances was only able to progress southward out of the Erie basin to or just slightly beyond the escarpment (Figure 25). These three advances are named, from oldest to youngest, the Lavery, Hiram, and Ashtabula advances. By about 11,500 years ago the last of the glaciers had melted back out of Erie County and was

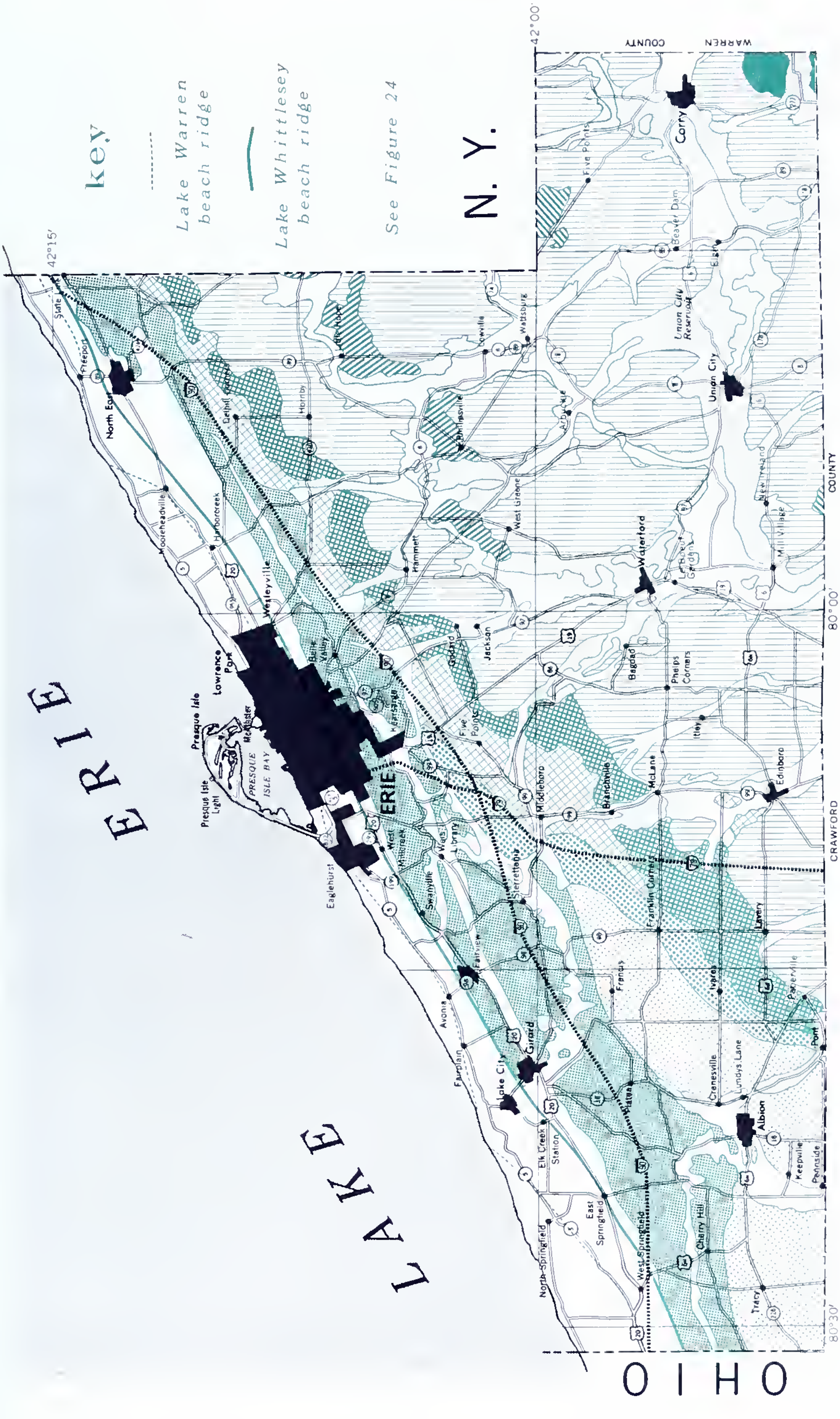


Figure 25. Map showing Erie County's glacial deposits.

retreating northward into Canada. Though this large continental glacier had minor later readvances, these never progressed far forward and never carried ice out of Canada. The ice cap remaining today on Greenland is the dying remnant of this once huge ice cap.

The effect that this Pleistocene glaciation had upon Erie County cannot be minimized. The glaciation formed Lake Erie and the lake plain, and by the deposition of vast quantities of sediment all over the county's surface it established the present drainage network and the many lakes and swamps that dot the countryside. It caused an entirely new sequence of soils to form, and it provided new resources by depositing sands and gravels and leaving bogs which allowed the accumulation of peat.

The Glacial Legacy

Ice crossing Erie County brought from the north great quantities of sediments. Early ice sheets, which progressed to many miles south of Erie County, ground their way across the land surface smoothing out the topography and picking up materials loosened from the bedrock. As these early ice sheets melted away, they left piles or blankets of mixed sediments covering the landscape. Flowing waters, which are abundant during the period of ice melting, also deposited sorted sands and gravels as scattered piles, ridges, or as stream fillings across the landscape. It is known that fillings by early ice advances were sufficient to block the preglacial stream system and turn the major drainage from flowing to the north to flowing in a southerly direction.

But the invasions of the late Wisconsin ice advances have removed nearly all of the earlier deposits except for the fillings in deep valleys. Just how much the landscape of the county was modified by the erosion of the early ice sheets is not known, though modification by continental glaciers is usually one of smoothing. Erie County probably had a somewhat more rugged appearance before glaciation. The escarpment area especially would have received the brunt of the glacier's attack. The pattern of the glacier's outer border in the latest glaciations as shown in Figure 25 shows the effect of the escarpment upon the glacier's movement.

Deposits of the Kent, Lavery, Hiram, and Ashtabula ice advances cover the surface of the county (Figure 25). Deposits of later advances generally cover the deposits of the earlier one so that the pattern of the various deposits shown in Figure 25 also shows the areas invaded by the successive ice movements. Note that the successively later ice masses moved shorter and shorter distances into the county. The Titusville and Kent ice covered all parts of the county and blanketed the entire area with a smooth-surfaced ground moraine composed of 10 to

40 feet of till (unsorted material laid down directly from the ice). The Kent deposits cover the Titusville deposits so that it is not certain what portion of the till blanket is Titusville material and what portion is Kent. Both tills are compact mixtures of loam or sandy loam containing an abundant quantity of pebbles.

The decay of the Kent ice was accompanied by the movement of large quantities of water. In addition, the content of materials carried by the ice was fairly coarse grained, i.e. sands, silts, and pebbles. Consequently, deposits of water-borne materials abound in areas invaded by the Kent ice. Valley bottoms such as those in the Corry-Union City-Waterford area are choked with mounds of sands and gravels (called kames) laid down by Kent meltwaters (Figure 26). A by-product of this valley-bottom deposition was the disruption of drainage in most valleys and the formation of numerous isolated lakes which, through the years, filled with silts and clays and, in some cases, with peat. The flat floors of most valleys in southeastern Erie County represent the surfaces on lake deposits or on glacial outwash laid down by streams draining from a nearby ice front (Figure 27). Fills in these valleys of 300 to 400 feet deep are not uncommon.

The Kent ice, in its stagnation and retreat, re-formed on several occasions and progressed forward again for a short period of time. These readvances were sufficient to produce ridge-like deposits of till along the re-formed edge of the ice. These are called recessional moraines, as compared to terminal moraines which form at the outer edge of the original ice advance. The terminal moraine of the Kent advance is known as the Kent moraine; it exists as a ridge from Warren to Lawrence Counties and cuts across southeastern Erie County. The recessional moraines of the Kent advance are best developed in New York State, where they were given the names Clymer and Findley Lake; their westward extensions reach into Erie County (Figure 25). Unlike the smooth-surfaced ground moraine, the terminal and recessional moraines have irregular hummocky surfaces.

When the Kent ice finally decayed and its front melted back into Canada, it formed a dam for waters draining into the Erie basin and a lake formed in front of the ice. Because the landscape had been denuded of vegetation by the glacier's advance, rivers draining into the lake were heavily laden with silts and clays and layers of these materials formed on the lake bottom. When the ice mass again began to push forward as the Lavery advance, it overrode these sediments, picked them up, and carried them into Erie County. The till which formed when the Lavery ice decayed was a fine-grained till, high in silt and clay and with a relatively small content of pebbles.

The retreat of the Lavery ice front into the Erie basin once more

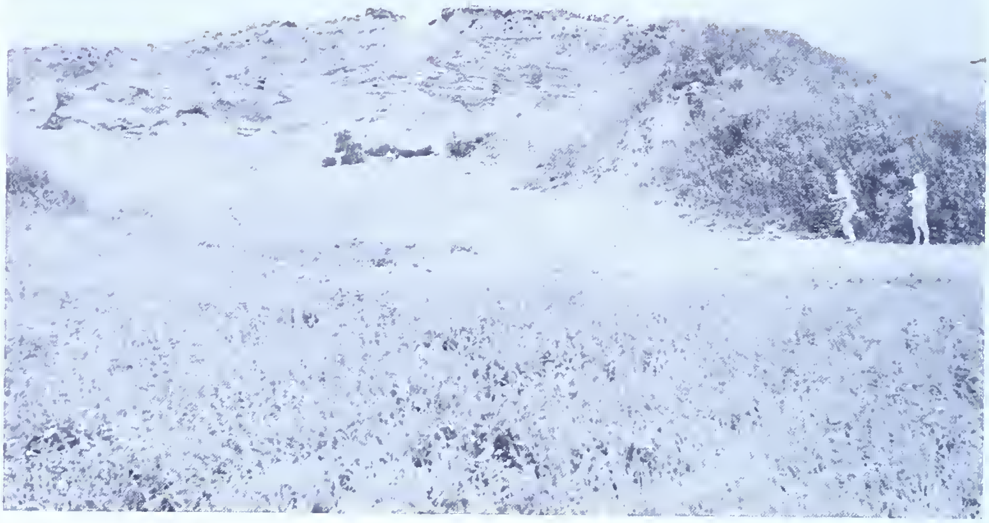


Figure 26. Small kame near Union City whose interior structure was exposed by sand and gravel operations.

Figure 27. Flat-floored valley formed on a fill of glacial outwash known to be at least 400 feet thick. Scene near Waterford looking west.

ponded the drainage and sediments again poured into the lake. The readvance of the Hiram ice, like the Lavery ice, picked up large amounts of the lake materials and deposited a fine-grained till. The Hiram till in many areas contains as much as 50 to 60 percent clay and generally has very few pebbles.

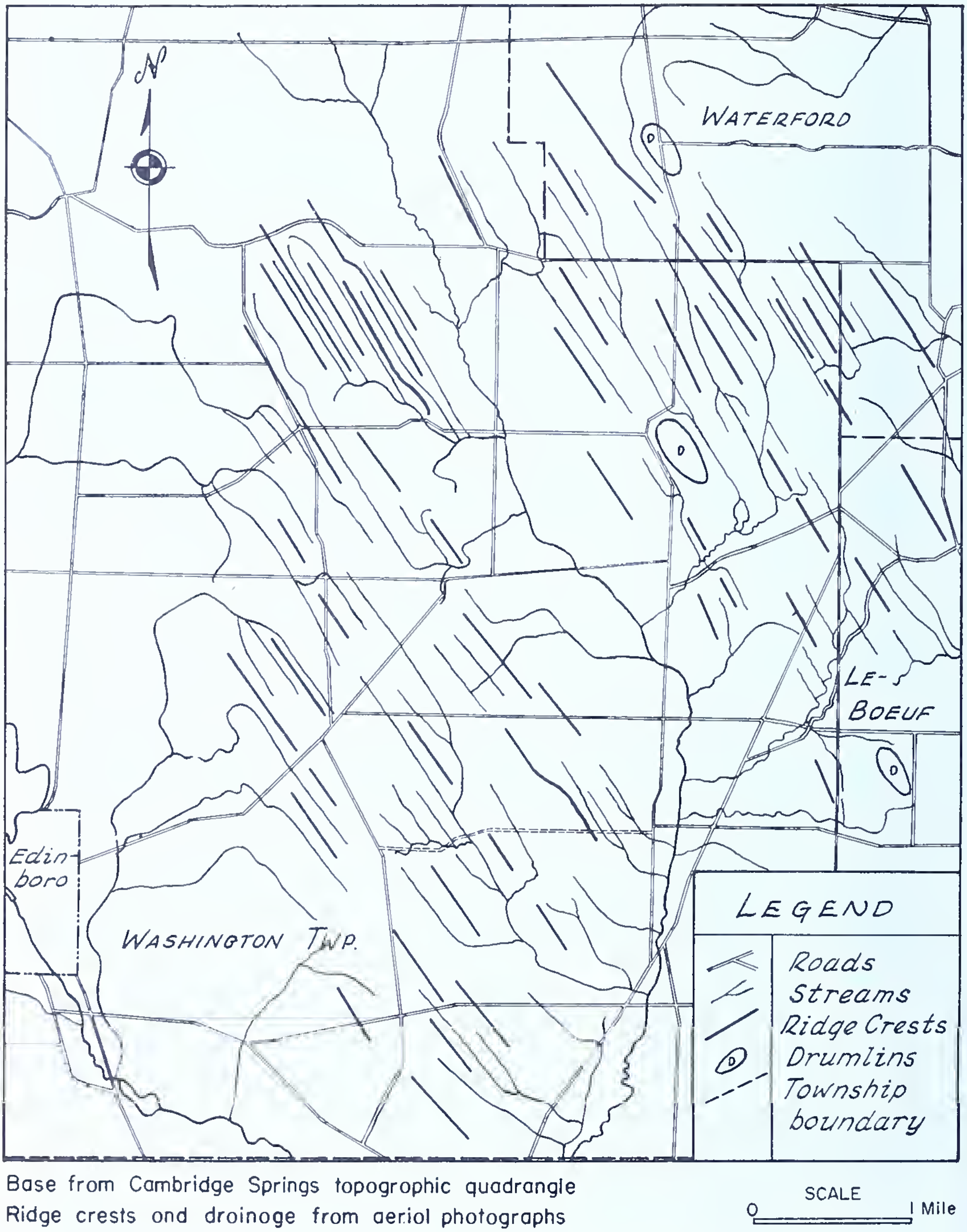
Kame development during the Lavery and Hiram stagnations was held to a minimum because of the fine-grained character of the ice's load and because much of the meltwaters were ponded so that they had no flow and could carry no load of sands and gravels.

The Ashtabula advance followed once more the retreat of an earlier ice advance, the Hiram, which had blocked drainage and caused the formation of an ice-front lake. Consequently, as with the Hiram and Lavery advances, the Ashtabula deposits are fine grained and are high in silt content. The Ashtabula till has more pebbles than the Hiram till. The Ashtabula ice did not advance sufficiently far to override the escarpment and did little more than fill the lake basin. All along its southern margin it formed a progression of en echelon terminal moraines, the surfaces of which are highly irregular and dotted with undrained depressions and small lakes.

Waters along the southern margin of the Ashtabula ice were locally ponded or flowed westward along the ice margin. The valley bottom of Conneaut Creek west and south of Albion is filled with clay layers which formed in an ice-front lake at the time the Ashtabula ice stood just north of Albion. The lake was drained when the ice retreated slightly north and began forming a second end moraine. Drainage was along the present path of Conneaut Creek and, in fact, it was at this time that much of the course of Conneaut Creek was established.

As the Ashtabula ice slowly retreated eastward out of the Erie basin, the basin was filled with water. The level of the water was controlled by outlet streams flowing past the edge of the ice toward the east. Water levels held for many years at relatively uniform heights then suddenly were lowered as the retreating ice opened a new, lower outlet. With final retreat of the ice out of the Erie basin, the lake assumed its permanent outlet through the Niagara River. Lake Erie was established at that time. The history of all the Great Lakes follows a similar pattern, for none of them existed prior to glaciation.

It was during the time of the higher level lakes in the Erie basin that the lake plain was formed. The lake plain represents a combination of lake bottom sediments and beach ridges formed along the lake margins as the lake stood at successively lower levels. Further discussion of early Lake Erie will be given in a later section on the Waters of Erie County. A complete history of the Great Lakes is given in a book called "The Geology of the Great Lakes" (See reference list).



Base from Cambridge Springs topographic quadrangle
Ridge crests and drainage from aerial photographs

Figure 28. Oriented and aligned surface features produced by glaciation in the area northeast of Edinboro. (From Shepps and others, 1959, p. 7.)

The glacial legacy bestowed upon Erie County by the ice exists most notably in the presence of Lake Erie and of the glacial deposits, the former because of its effect upon trade and climate and the latter because they contribute not only mineral deposits, but because they form the foundation for new, more fertile soils. A secondary legacy lies, however, in the scenery produced by the glaciation. The terraced lake plain overlooking Lake Erie and the fascinating sand spit known as Presque Isle characterize the county, but many alterations in the character of the uplands can be traced to glaciation. The flat valley floors leading to irregular-surfaced kame deposits spotted with ponds and swamps did not exist before glaciation. These attest to the formation of scenery by glacial deposition. No less notable, however, is the scenery produced on the uplands by the sculpturing action of the ice mass. In the upland area between Edinboro and the New York State line, the land is streaked out into long, parallel ridges and valleys oriented in the direction of ice flow (Figure 28). Further east toward and beyond Wattsburg the streaked surface gives way to scattered, oriented, spoon-shaped hills, called drumlins (Figure 29). Erie County has the only drumlins in Pennsylvania. Drumlin development reaches its peak eastward in New York State.

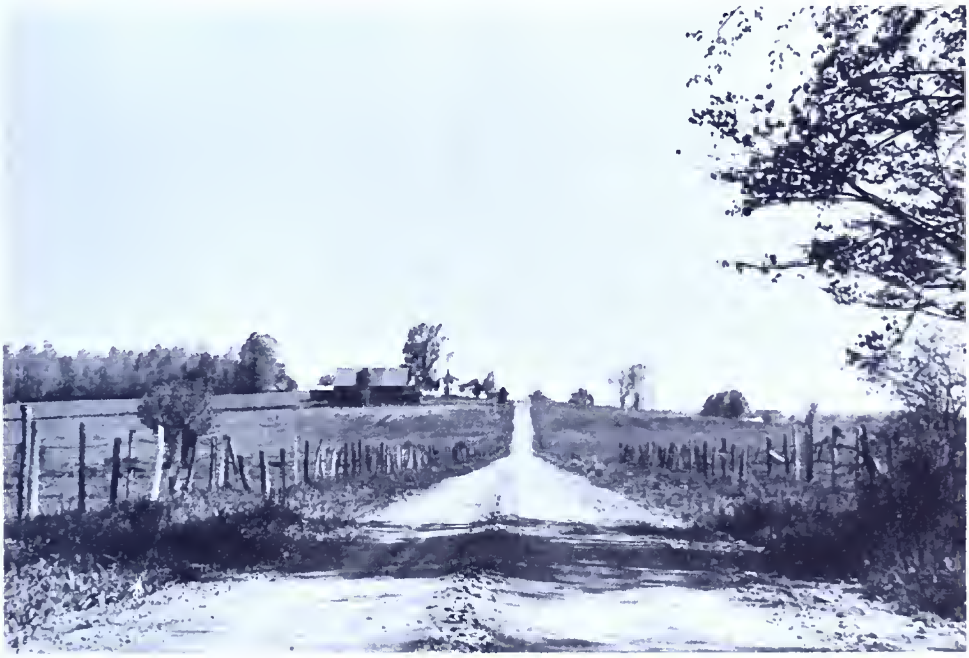


Figure 29. View toward the long side of a drumlin in Erie County.

THE WATERS OF ERIE COUNTY

Erie County lies in an area of abundant rainfall so that one need not travel far to encounter water at the surface. Surface water occupies streams, swamps, and lakes and though it may appear at times to be motionless it is constantly on the move and is continually being replaced. Movement of water in streams is apparent; movement in lakes and swamps is slow but the fact that nearly all of these features feed a stream implies that they are being drained. Waters are also removed from the land surface by evaporation into the air either directly from a water surface, or indirectly through transpiration by vegetation. This loss is unseen, but represents a sizeable quantity. Another unseen loss of surface water is by infiltration into the underground. Water in storage in the pores and crevasses of the subsurface soils and rocks moves slowly and represents a sizeable reservoir of water to be tapped when the need arises.

SURFACE WATERS

A major drainage divide splits the county into two separate drainage systems, one flowing southward sending waters eventually to the Gulf of Mexico and the other sending waters northward via Lakes Erie and Ontario and through the St. Lawrence River to the northern Atlantic Ocean. Prior to glaciation all of Erie County's waters flowed to the Atlantic by the St. Lawrence lowland route.

The drainage network and the distribution of lakes and swamps were established as ice of the glacial invasions melted back from the county. Many of the major valleys trace back to preglacial times, but the streams they now contain may be larger or smaller and may even flow in a different direction than the early preglacial streams. In many valleys, streams now flow on deep sediment fills hundreds of feet higher than the levels at which the early streams were flowing.

The Divide

The present-day divide, shown in Figure 30, is probably not substantially different in location from the preglacial divide. Comparison of the drainage map (Figure 30) with other maps (Figures 4, 19, and 25) shows that the position of the divide is not controlled by the distribution of bedrock and that it does not trend across the highest parts of the county. Rather it is seen to be running irregularly just south of the rim of the escarpment. Its exact position is modified locally where the Lavery moraine lies at the escarpment rim; the position in these cases is determined by the crest of the moraine.

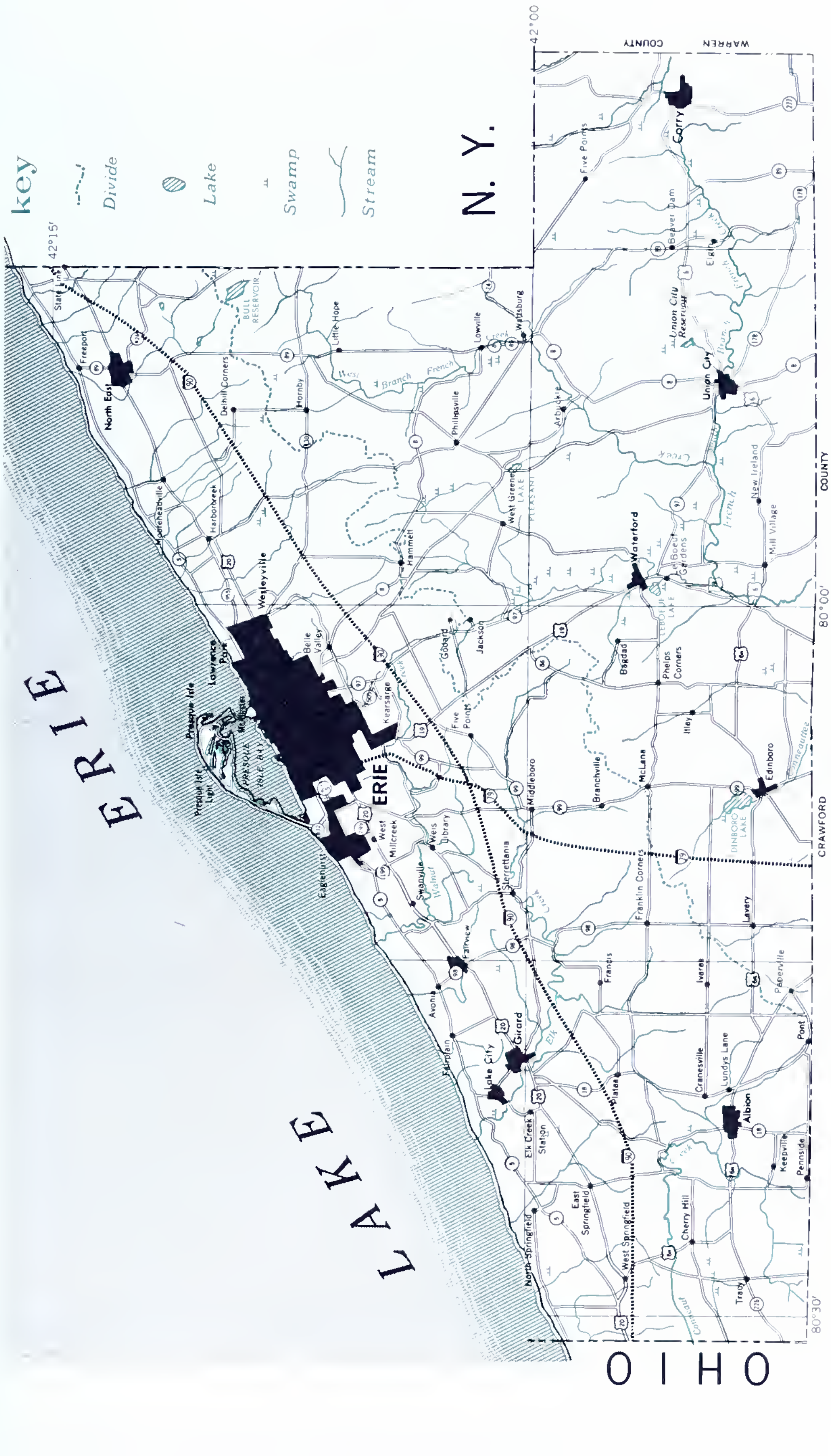


Figure 30. Map of the surface waters of Erie County. Hundreds of small swamps and ponds are not shown.

Streams

Nearly all streams south of the divide, draining south, are tributaries to French Creek. A few streams in and around Corry drain into Hare Creek and thence to Brokenstraw Creek. Larger streams in the French Creek system flow on deep fills in broad, preglacial valleys. The valleys, because they drained southward, carried off sediment-choked drainage from the ice front. Waters flowing southward quickly dropped their load of sands and gravels and built up flat-topped fills which slope gently downstream. This slope to a large extent controlled the direction of post-glacial drainage.

Some valleys did not permit through-flowing drainage of meltwaters because they were filled with kames or moraine or with unmelted blocks of ice. Such areas displayed highly irregular topography and abounded in lakes and ponds of all sizes. Some of the larger lakes remain today, but most have filled with sediments or vegetation and remain as swamps or as poorly drained depressions. The highly irregular topography has since been modified somewhat but an efficient drainage system has yet to be developed in many of the kame areas and many valley bottoms.

North of the divide, streams and their valleys have a notably different character. Many streams flow in narrow, steep-walled, shallow or deep valleys. It is obvious in most cases that the stream itself has cut its own valley, even though the path it chose may have been dictated by existing influences. Bedrock floors are common, especially beneath streams flowing down the escarpment face and across the lake plain (Figure 21). Even in the area of the Lavery Moraine where glacial sediments are sometimes thick, streams have cut deeply into bedrock. (Figures 9 and 22).

The paths of most streams north of the divide are directly northwestward down the prevailing land slope. South and west of Erie, however, the presence of glacial drainageways in front of the multiple end moraines of the Ashtabula advance (Figure 31) has diverted most streams so that their initial northwestward flow is turned toward the west and even the southwest. Eventually, following an irregular path, they reach Lake Erie. Notable examples are Walnut and Elk Creeks; most notable is Conneaut Creek which, after approaching within about 5 miles of Lake Erie near Albion, turns southwestward into Ohio, then turns to the northeast and finally reaches the lake after a 22½-mile journey.

Swamps

Swamps represent a condition in which the level of the ground water nearly coincides with the surface of the land. This situation is created where water is standing at the surface through most of the year;

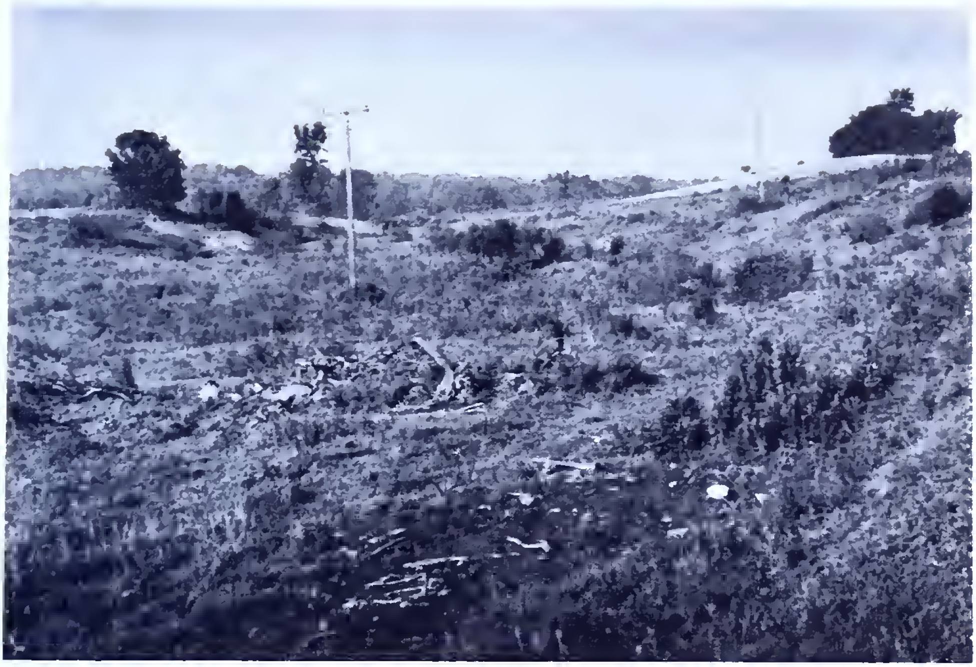


Figure 31. A now-dry channel which during the melt back of the Ashtabula glacier must have carried away large flows of water.

a swamp frequently represents a place where ground water is discharging onto the surface. Vegetation which can endure "wet feet" populates the area. Swamps exist as the dying stage of most lakes or along the margins of lakes where water is shallow due to sediment influx. Swamps frequently occupy stream channels recently abandoned by actively migrating streams; the valley of West Branch French Creek contains many such swamps.

Small swamps abound in morainal areas, especially in the Ashtabula end moraine. Large swamps exist in valley bottoms south of the divide especially near Waterford and between Union City and Corry. A notable swamp at Edinboro (Figure 32) demonstrates the demise of a lake; the area was once a kettle lake, a companion to Edinboro Lake. An equally interesting swamp may be viewed from Route 6 about a mile east of Union City (Figure 11); the destruction of a lake is vividly demonstrated here because a map published in 1929 (U. S. Geological Survey's Union City 15-minute quadrangle) shows an open lake in existence at this site.

A special variation of the "swamp" is a peat bog. Peat bogs of various sizes are scattered in parts of Erie County. In lakes where sediment influx is kept to a minimum, the last filling may be by thick accumulation of organic matter, especially sedge, shrubs, and trees with some moss. An active bog of this sort is Hells Half Acre on State Game

Lands 102 north of Union City. Completely filled bogs exist near Corry, west of Edinboro, north of Union City, west of Waterford, and northwest of Wattsburg. The peat in many of these bogs lies in reserve as a resource for future development. One bog is being currently worked near Corry as described later in this book.

Lakes

In addition to Lake Erie, three small natural lakes exist in Erie County. All three lie about 15 miles inland from Lake Erie (Figure 30) and represent kettle lakes, i.e. lakes formed when ice blocks were buried in outwash sediments, subsequent melting of the ice creating a water-filled depression.

Edinboro Lake is the largest of the three, measuring one and one-quarter miles long by about half a mile wide (Figure 33). Oldtimers in the area still refer to the lake as Conneautee Lake and the name is being revived by some mapmakers. The lake is approximately 40 feet deep at its center. It is nearly surrounded by residences in and north of the borough of Edinboro. A small dam raises the water level about 10 feet above its natural position, serving to stabilize shore developments.

Lake Le Boeuf, adjacent to the borough of Waterford, is the second largest of the county's inland lakes. It is three-quarters of a mile long and half a mile wide. Its greatest depth is 40 feet. The waters of Le Boeuf Creek and Trout Run enter the lake from the north; the lake is drained southward by Le Boeuf Creek which shortly enters French Creek. Tagged muskellunge placed in the lake by the Pennsylvania Fish Commission have been recaptured from as far away as Marietta, Ohio.

The third largest inland lake, Lake Pleasant, is both fed and drained by very minor streams. The lake, which is slightly smaller than Lake Le Boeuf, lies in the bottom of a glacially filled and choked valley at an elevation of 1302 feet. The valley which would appear to have carried a moderate-sized stream in preglacial times is today the site of a number of small lakes, in addition to Lake Pleasant, and of a rather large swamp. Drainage from the lake is into French Creek. The lake is an angler's delight, especially for trout fishing; night fishing is practiced with fishermen dropping weighted lines to the full 50-foot depth of the lake.

Scattered throughout Erie County are numerous small ponds, many of which are kettle lakes. These are particularly abundant in the western portions of the Ashtabula Moraine and in valley bottoms south of the divide. At one time Erie County must have been freckled with such small ponds, but most have filled with sediments and have become either swamps or undrained depressions containing dark-colored soils.

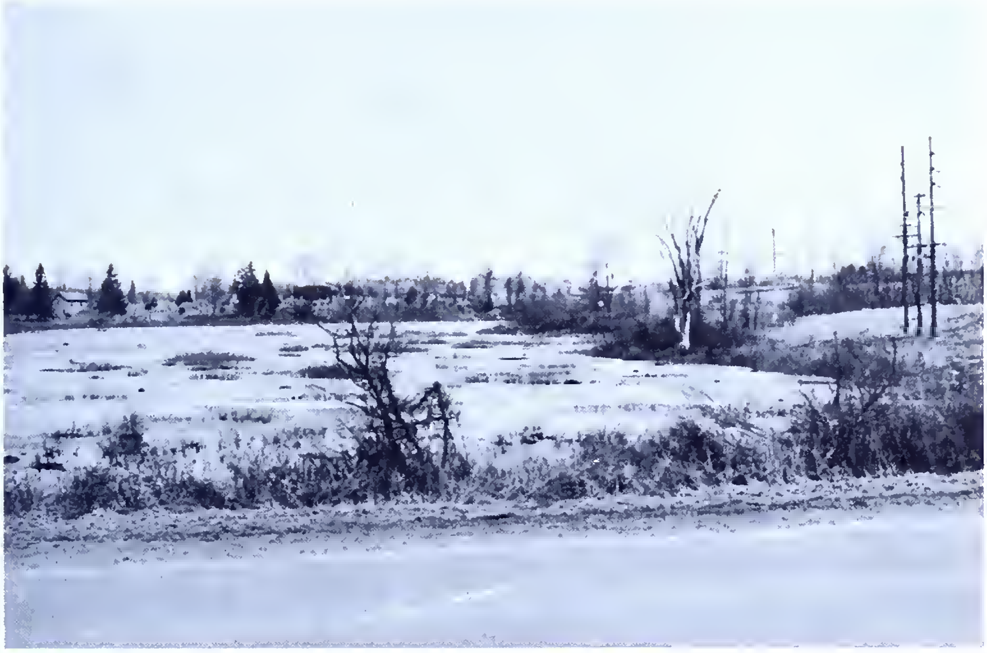


Figure 32. A large swamp at Edinboro created by the complete infilling by sediment and vegetation of a kettle lake. This lake, before its demise, must have looked very similar to Edinboro Lake.

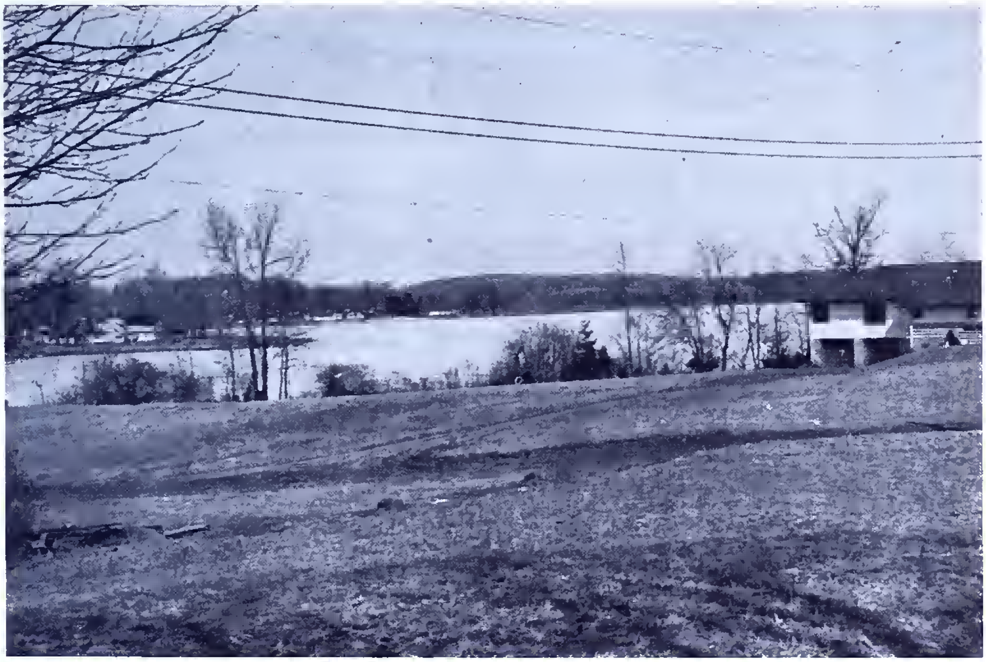


Figure 33. A view of Edinboro Lake, the largest inland lake in Erie County. The lake is a kettle lake, that is, its basin formed by melting away of an ice block which was buried in glacial outwash.

Lake Erie

Lake Erie is the second smallest of the Great Lakes, measuring 241 miles in length and varying in width from 30 to 57 miles. It is the shallowest of the Great Lakes with a maximum depth of 210 feet. Its surface is 572 feet above sea level and its area is 9950 square miles. Elevation of the surface is known to vary and the figure of 572 feet is a 100-year average; the level measured in 1876 was 574.4 feet.

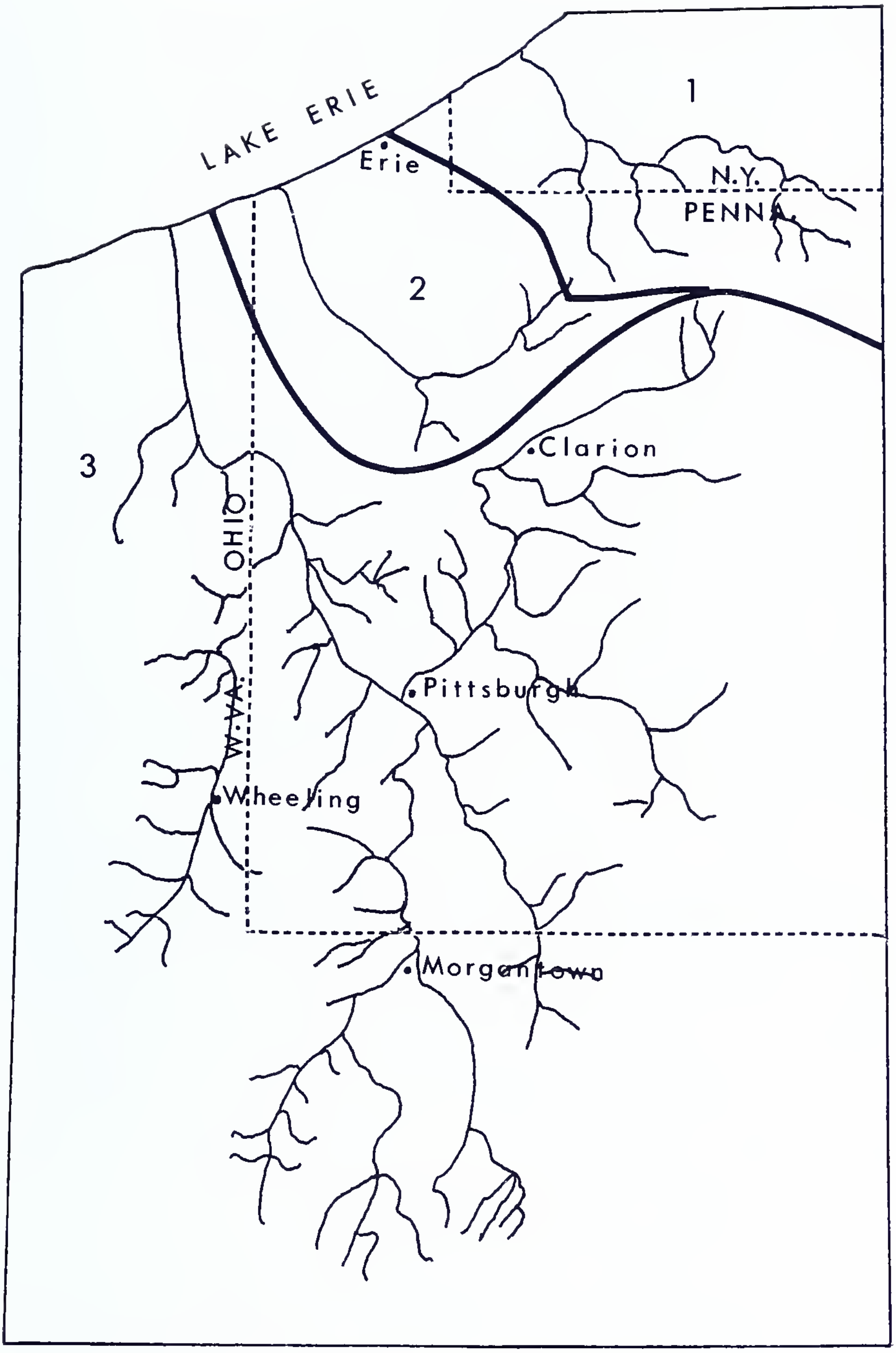
Lake Erie is fed mainly by the Detroit River flowing from Lake Huron and it is drained by the Niagara River flowing to Lake Ontario. The lake receives runoff from 34,680 square miles of land. Drainage into the lake carries with it muds and sands which are accumulating on the lake floor at the rate of 3 inches per year. If filling of the lake continues at this rate, and there is no reason to expect a change, the lake has a life expectancy of about 100,000 years. This figure is reduced somewhat, however, by the fact that the outlet of the lake, Niagara Falls, is constantly receding toward the lake at a rate averaging 4 feet per year. As the outlet recedes, it is also lowered with an attendant lowering of the lake level. Barring the construction of artificial controls the Niagara River should start seriously draining the lake in about 27,000 years.

Erosion on the southern shore of Lake Erie is rapid. Lake water levels vary as much as 4 feet in places with varying weather conditions. Storm waves have been measured to break as high as 15 feet. Ice dams and their subsequent welling have caused abnormal erosion in many places. In some cases the accumulation of ice has prevented erosion by the strong wave action of winter and early spring. Tidal action has been measured at about 9 inches maximum.

Evolution of the Drainage System and Lake Erie

Prior to glaciation, all of the surface drainage of Erie County moved to the northern Atlantic Ocean through a major river system which flowed down the Erie basin and the St. Lawrence lowland. At that time, Lake Erie did not exist and the Allegheny-Ohio river system was not established as we know it today.

Instead, three separate “Allegheny” systems (Figure 34) gathered water from northwestern Pennsylvania and moved it northward through New York, Pennsylvania, and Ohio instead of southward as it is moved today. French Creek drained southward into the ancient “Middle” Allegheny River to drain most of Erie County south of the divide. The Allegheny then flowed southward past Oil City toward Franklin as it does today. But at Franklin it flowed toward the northwest almost to Meadville, then moved through the Conneaut Outlet and the valley of Con-



1. UPPER ALLEGHENY DRAINAGE SYSTEM
2. MIDDLE ALLEGHENY DRAINAGE SYSTEM
3. LOWER ALLEGHENY DRAINAGE SYSTEM

Figure 34. Map showing major drainage network in northwest Pennsylvania prior to glaciation (Modified from Leverett, 1902).

neaut Lake, past Conneautville and Albion and northward downslope into the Erie basin. The deep valley which carried this stream has been partly or completely obliterated by glacial filling. The buried valley is thought to exist under the valley of the present Crooked Creek; depths to bedrock along the course of this valley are known to exceed 300 feet near Conneaut Lake and 500 feet in Conneaut Outlet. Most water wells drilled along the course of the valley have found water before reaching bedrock so that information on the depth and trend of the main valley is lacking.

As successive glaciers overran northwestern Pennsylvania, existing valleys were filled in part or completely with sediments. As the glaciers reached the position of their maximum advance and began to melt, large quantities of water were produced which, using existing valleys in front of the ice, created a major south-draining river system. As the ice front melted back, successive drainage was connected to the south-flowing system.

The drainage network which existed in preglacial times is not known in detail. Nor is the history of drainage changes known in detail. Some mystery exists, for example, in the early routes used by the French Creek system; it is doubtful if flow then was similar to that of today's French Creek. Investigations needed to define in detail the early drainage systems have not been conducted.

As the edge of the glacier receded by melting, a lake formed in front of the ice wherever landslope was toward the ice. Water levels in the lake were controlled by the elevation of whatever outlets were available. As the ice receded into the Erie basin, water was backed up over a large area, the lake being drained westward through an outlet down the Wabash River. This impoundment was ancestral Lake Erie.

As the ice continued to recede eastward and northward, successively lower outlets were opened. The sudden opening of new outlets caused the lake in the Erie basin to fall to new levels rather rapidly. Consequently, the basin contained a sequence of lakes each of which existed at a stable level for a relatively long time. As each lake stood at its chosen level, it developed a beach ridge around its margin and bottom deposits spread out over its floor. When water level dropped to form the next lake, the beach of the previous lake was abandoned to form a huge broad step along an otherwise flat shoreline. Each successive lake left a similar step.

The lakes in the Erie basin have been named. Lake Erie at elevation 572 feet represents the final lake level, its elevation being determined by the level of the bedrock under the Niagara River upstream from Niagara Falls. Once the ice receded from the St. Lawrence valley about 10,000 years ago, the level of Lake Erie had been established. Successively older lakes in the Erie basin which may have existed in Erie County are listed below, from youngest to oldest, with the approximate height of their surface:

Lake Lundy	640′
Lake Warren	700′
Lake Whittlesey	760′
Lake Maumee	840′

Clear beaches exist in Erie County only for Lakes Warren and Whittlesey (See Figure 25). Lake Lundy was a short-lived lake whose beaches fall near the present lake bluff. Lake Maumee existed at a time when ice stood over much of northern Erie County so that the lake would have contacted only the westernmost part of the county. Traces of its beach are obscure.

The early phase of present Lake Erie stood lower in elevation than the present lake because the mass of ice lying east and north of Erie County depressed the earth's surface. After the glaciers melted completely, uplift of the land surface raised the Niagara River outlet and increased the level of Lake Erie. At the same time, the earlier formed beach ridges along the Erie shore were tilted by being raised on the east. The Lake Warren beach ridge, for example, rises about 30 feet in elevation from the western Erie County line to the eastern line.

SUBSURFACE WATER

Beneath the ground lies water, not as lakes or pools as some would claim, but as crack or pore fillings in a saturated sponge. Rarely is the ground saturated with water right to the surface, except near swamps or bodies of water. In most places one would have to dig to some depth to encounter standing water. The level of that water represents the top of the saturated zone, called the water table.

The top of the water table beneath Erie County lies at varying depths. It is at the surface in very low, swampy areas and at greater depths as the land rises. Wells penetrating glacial deposits frequently yield usable quantities of water after the water table is penetrated. Yields are especially high in low gravel areas, especially in valley bottoms or where buried and filled valleys are encountered. Wells in these areas yield the only large quantities of water available from the subsurface in the county. Small domestic supplies are available from glacial materials nearly everywhere in the county.

A common proverb maintains that deep-well "rock" water is the best, but the man who said it was not an Erie Countian. A consideration of the bedrock column shows a preponderance of shale in the near-surface bedrock of the county. Because the pores of shales are small and poorly interconnected, the rock yields only minor quantities of water to wells. Moreover, drilled wells, especially those near Lake Erie, commonly encounter salty waters, sulphurous waters or even gas at shallow depths. At best, bedrock under most of the county yields meager water supplies.

THE RESOURCES OF ERIE COUNTY

SAND AND GRAVEL

The largest income from mineral resources in Erie County is derived from sand and gravel production. There are numerous operating pits; many are small and individually owned. Farmers of the plateau region commonly establish small operations to obtain gravels for constructing their own roads.

There are five major sand and gravel companies which produce an estimated 300,000 tons of products annually. During years of rapid highway construction the production has reached nearly 500,000 tons.

Two other large companies rely on sand dredging in Lake Erie. These produce concrete sands, masonry sands, and grit. The U.S. Coast Guard locates the deposits and notifies the companies where the bars are formed. Since much of this production is not off Erie County shores it would be misleading to include this production in county figures. However, in an average year, some 110,000 tons of this sand is sold within the county.

The total sand and gravel tonnage from all county sources probably exceeds 500,000 tons annually.

The most active pits are west of Wattsburg, at the lake at North East, south of Wesleyville, at Fairview, and east of Girard. The actual sand and gravel reserves of the county probably run into millions of tons since many of the kames and kame terraces have not been exploited.

PEAT

The original distribution of peat bogs was discussed earlier in describing the glacial legacy. Only one of the county's peat bogs is being exploited at this writing; it is located slightly northwest of Corry.

The bog operation today covers nearly 50 acres of land (Figure 35). Ditches are dug to a depth of three feet and the water table is lowered through these to a small stream which flows eastward. The peat is then scooped up with power shovels in much the same way that the gravel operations are conducted. A new system of recovering the peat is being installed at Corry. In this system the pit area is flooded and pumps with cutting bits are lowered into the peat. The peat and water mixture is pumped to a large but shallow excavation where the materials are allowed to dry. After drying, the mass is crushed and processed in the same fashion as if it were mined by shovels and trucks. It is then stored in open sheds until marketed (Figure 36).

Corry peat measures 2½ cubic yards per ton. It is used for agricultural purposes and, after blending with sand, for tennis court surfacing.

The deposits at Corry have reserves in excess of 3 million cubic yards. The combined reserves in smaller bogs in the county probably exceed those at Corry.

GAS

One of the county's largest mineral resources is gas and the production of this commodity is steadily increasing. Erie has been a small but steady producer of gas in the past. It did not produce the amount of other gas producing counties but its potential became realized in the early 1960's. In 1961 there were eleven exploratory wells drilled and one of these located at Lundys Lane opened up a new pool. During 1964, 30 wells were drilled in the county, and in 1965 the number increased to 70 wells.

Since the early days of gas exploration around 1912-13 there have been over 325 wells drilled within county limits. Many of these are still producing small quantities of gas while others are used for gas storage by the Pennsylvania Gas Company.

A large tract or area of many square miles containing natural gas is known as a *field*. Divisions of fields are known as *pools*. For instance, Beaver Dam and Corry Pools are divisions of the Corry Field, (See Figure 37). Lexington, Lundys Lane, and Tracy Pools are divisions of the Conneaut Field.

Producing pools in 1962 were Lexington, Lundys Lane, Tracy, and Beaver Dam. The Burgess Field also was a producer. The field at Meade in Summit Township and the Corry Pool were used for storage purposes. Several isolated wells were shut in and are still capable of limited production.

Total gas production in 1961 was approximately 50 million cubic feet. In that year the Lundys Lane well was brought in with a production of 3 million cubic feet per day. The total commercial gas production in Erie County since 1912 exceeds seven billion cubic feet.

Gas production in the county today comes mostly from the Lower Silurian Medina Group (Figure 18). In these sandstones are located the producing wells of Lundys Lane Pool and the Corry and Burgess Fields.

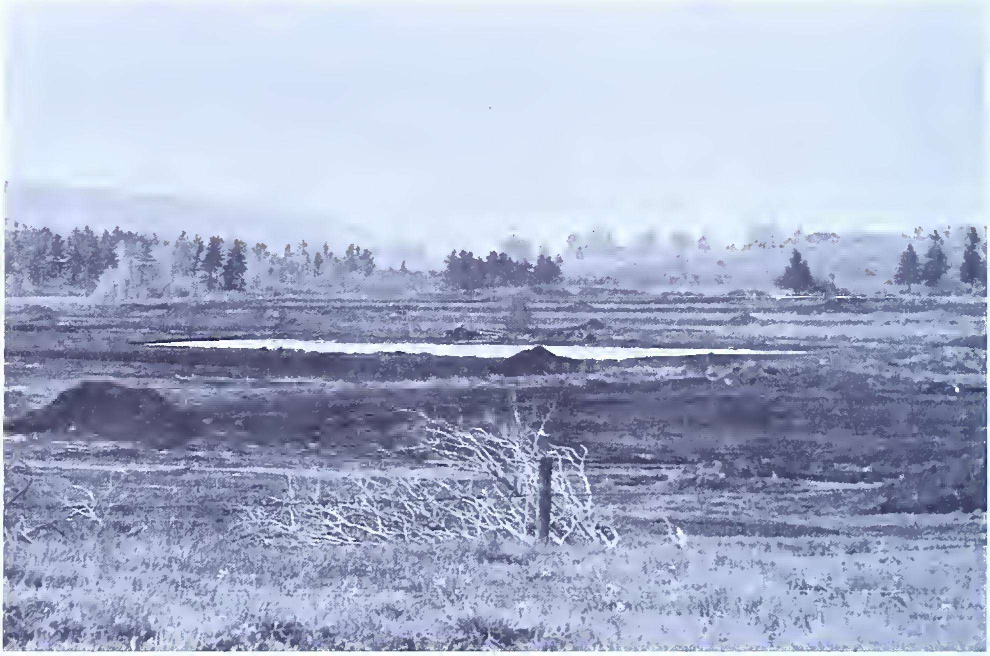


Figure 35. Peat bog north of Corry from which the Corry Peat Products Company is stripping peat.

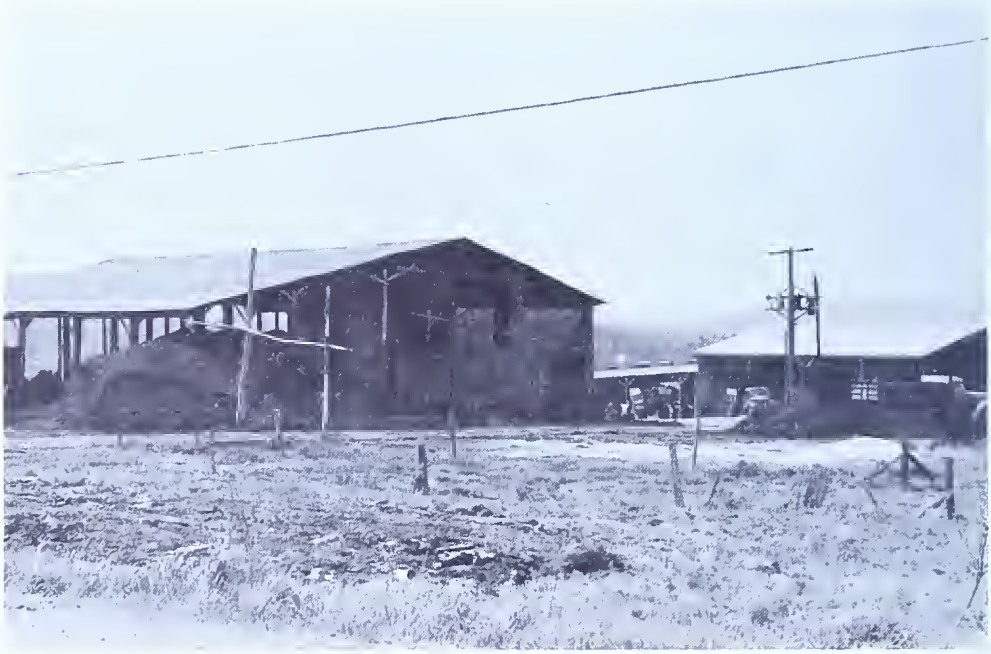


Figure 36. Open shed for peat storage at the Corry operations.

In the Medina sands the best gas production comes from the Grimsby Formation which is the upper part of the Medina Group. These fine and very fine-grained sandstones are overlain by the dense shales and dolomitic shales of the Clinton Group. Below this is the lower Medina sandstone known as the Whirlpool Formation; these are fine grained and yield small amounts of gas.

Although present production in the county is mainly from the Medina Group, the majority of past production was derived from the Meade Field, Summit Township. In the Meade Field the Oriskany Sandstone of Early Devonian age yielded almost 5 billion cubic feet of gas before the field was converted to gas storage in 1959. One of the wells of the Meade Field was sunk into the Gatesburg Formation of the Cambrian System. Here a small amount of gas was procured but not enough to justify keeping the well operating.

Gas is imported into the Erie area in large amounts from distribution points in Tennessee and the southwest. Local gas is mixed with the imported product. Gas is stored underground in the summer when consumption is low and used in the winter when the demand is greatest.

Interest in gas exploration in Erie County will probably continue as long as new discoveries are being made.

BUILDING STONE

There were over 40 active stone quarries in Erie County at the turn of the present century. Gradually, with the introduction of inexpensive concrete products these quarries were abandoned. Today none of the quarries are operating for the purpose of obtaining building stone. Periodically a quarry will be temporarily opened by the state or township road department in search of crushed stone for road fill. In the summer of 1963 some stone for this purpose was gathered at Howards quarry in Franklin Township.

Of the larger operations fourteen quarried the Panama Sandstone of the Cattaraugus Formation. These form a chain of quarries from the southern tributaries of Elk Creek to Waterford and east to Wattsburg. This fine-grained sandstone was used for many building purposes, especially barn and house foundations. Near Waterford the sandstone smells of oil.

There were six large quarries operating in the Canadaway Formation. At Walnut, Neelys Run, and Four Mile Creek the sandstones were quarried from the creek beds. There are three thin but solid sandstone layers from 25 to 65 feet above the lake level interspersed with the thin shales of the formation and these are the layers that have supplied the stone.

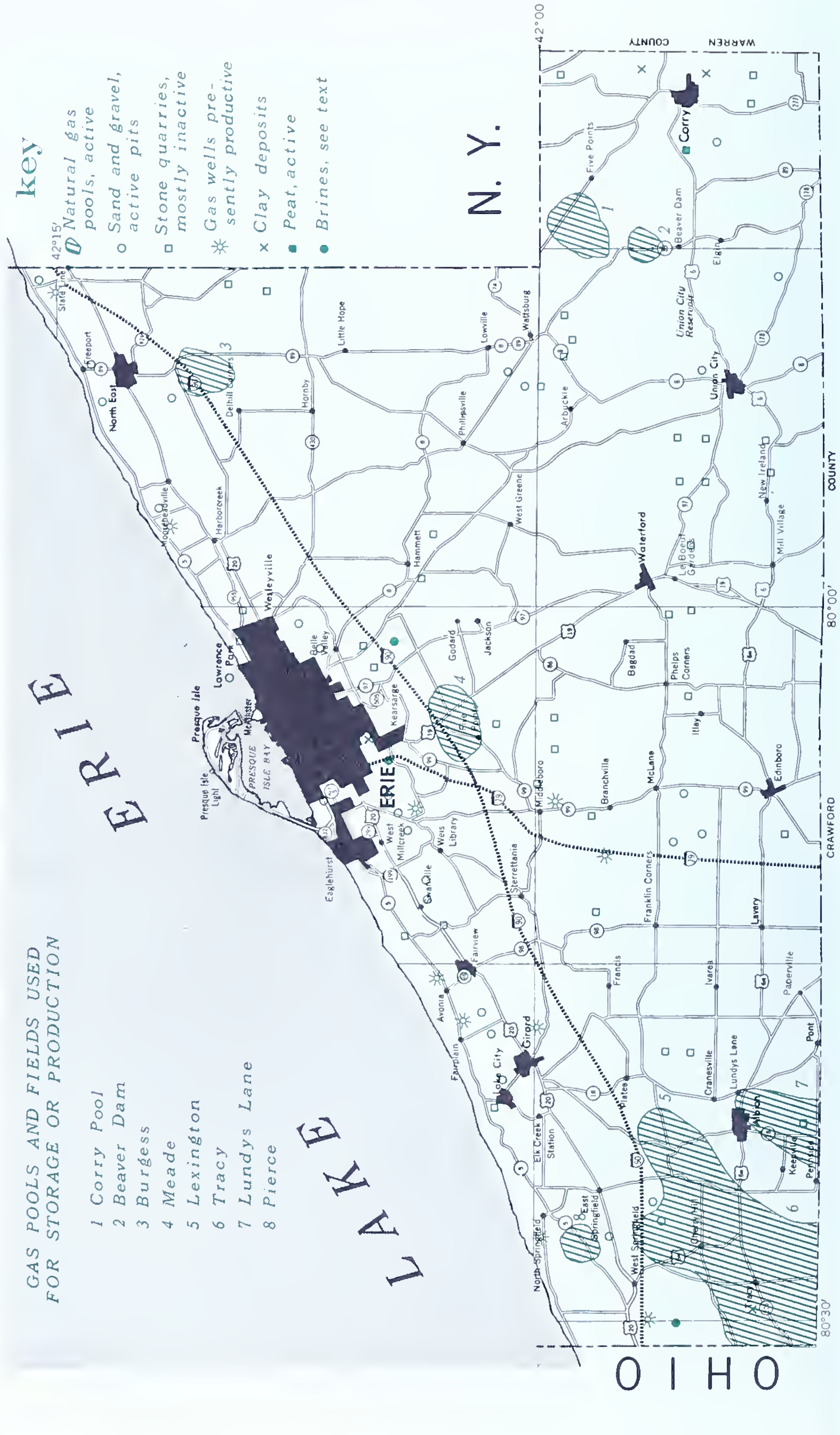


Figure 37. Mineral resources map of Erie County.

Two quarries were used extensively to supply building stone for the extension canals of the Erie Canal System. These were located at the McKean-Summit Township line and three miles east of Cranesville. Both of the quarries were operating in Le Boeuf Sandstone.

Four quarries obtained thin flagstones from the upper Conneaut strata. The largest of these was located near Middleboro.

Three quarries south of Corry worked the Corry sandstone. These are fine-grained white sandstones that can be quarried over a great area. In some places the sandstone contains fine round quartz pebbles, as described earlier.

An automobile trip over the county will demonstate the use of local stone to its greatest advantage. Many sandstones can be seen in barn and house foundations, chimneys, walls, bridge structures, walks, and steps. Often the sandstones are used in conjunction with massive crystalline igneous and metamorphic rock that have been carried to the area by glaciers. A house built of local stone may be seen in good repair on West 25th Street in Millcreek Township (Figure 38). It is safe to assume that any barn built before 1920 has some local stone used in its construction.

If the need should arise there are many tons of good sandstone waiting to be quarried. They are exposed close to the surface and can be obtained at limited expense. Today the stone is still more expensive

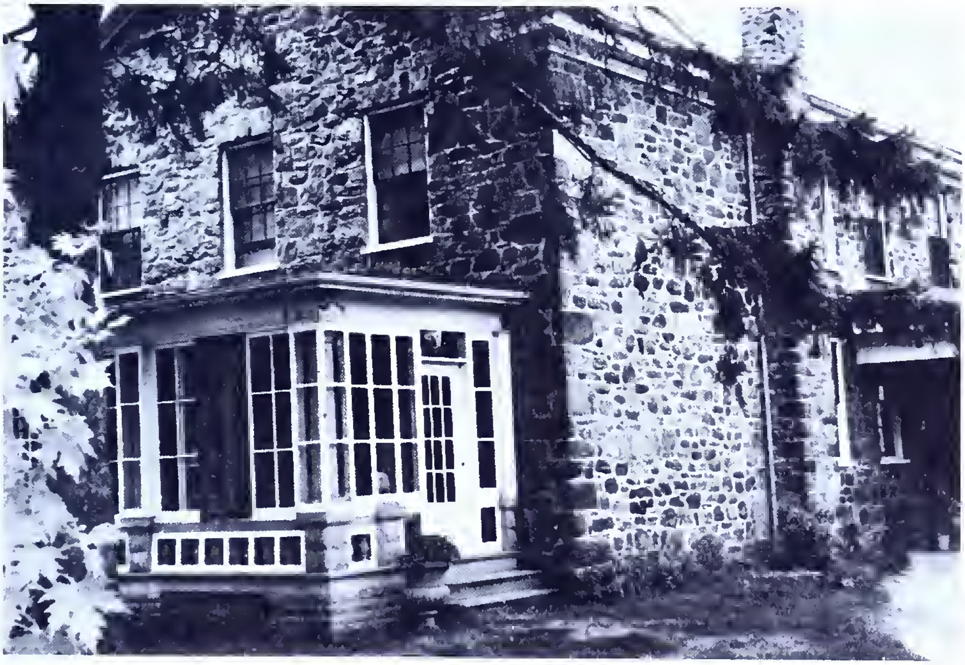


Figure 38. House built of glacial boulders and locally quarried bedrock.

than concrete for building purposes. Since sand and gravel is abundant within the county it is doubtful that the stone will be exploited for many more years to come.

OIL

Although traces of oil exist in surface rock formation and small oozes have been detected underground, oil in commercial quantities has not been found in Erie County. Oil shows were made in the Bass Island Group in a well drilled at North East and in the Lindsay Formation in a well drilled at Springfield. These had both produced a barrel of oil before drilling ceased.

The largest oil producing well was drilled at Summit Township in 1956. This well produced 5 barrels of oil before the oil stopped oozing after the first day.

Oil traces were also observed in the Oriskany sandstone, Onondaga Group, and the Gatesburg Formation.

It does not seem likely that oil in any commercial quantity will be found under Erie County.

CLAY

In the past, clay for brick manufacture has been obtained in many places within the county. Two places which have undergone considerable exploitation are located just south of Erie and west of Corry.

Clay deposits are found in small amounts in many of the tills. The fine unweathered blue clay on the lake cliff is referred to as Erie Clay and it was used for brick making in pioneer days. As late as 1900 brick from local clay was manufactured in Albion and Fairview. Many of the older buildings of those areas are of this brick. The Fairview Presbyterian Church built in 1875 is of local brick.

The southwestern portion of the county seems to be the best location for possible clay production. This is the area of the Hiram Till which contains a high proportion of clay that may be used for brick and tile production. Some shale bedrock units might yield useable clays.

WATER

The water resources of the county are adequate for future industrial and domestic expansion. Lake Erie is a huge reservoir of fresh water available to the county. Most of the streams flow constantly and these can be dammed for storage. With this in mind the amount of rainfall of the area is not a matter of great concern for industrial and metropolitan water purposes. The present inland water area is estimated at 7 square miles.

Measurements of the flow of Conneaut Creek over a 12-year period showed a capacity of 186 cubic feet per second. The flow of Elk Creek measured over a 13-year period was 128 cubic feet per second. Walnut Creek measured over an 18-year period had a flow of 29.6 cubic feet per second. Eastern streams were closer to the Walnut Creek figure.

The daily water use in the city of Erie was 36.6 million gallons per day in 1960. It is expected that this water consumption will double within twenty years due to the rapid expansion of industry within the metropolitan area served by the city.

The future water resources of the county must be judged not only by quantity but also by quality. Pollution has recently become a problem on Lake Erie and only by combined efforts of all states bordering upon the lake can this problem be solved. A few industries at Erie are experimenting with deep wells drilled into sandstone layers. If their liquid wastes can be absorbed by these sandstones without affecting water and mineral supplies then a knotty problem will have been solved.

Streams of the county are pure and are actively guarded by the Pennsylvania Fish Commission. Pollution violators are quickly apprehended and brought to justice.

A problem of water supply that must be considered is the occasional cloudburst that causes the creeks to overflow their normal banks and create havoc. A cloudburst of August 9, 1915 caused Mill Creek to rush through the city of Erie overflowing conduits and causing severe flooding and damage. Twenty-three lives were lost and over two million dollars in property damage was estimated. The total dead attributed to the storm was 37 persons. It had rained 5½ inches in less than 24 hours. Since then construction along the stream has eliminated the possibility of a recurrence of the disaster. In considering reservoir construction the possibility of rapid rushing overflowing streams must be made.

It may be possible to renew underground water sources of the county by finding suitable aquifers and pumping Lake Erie water into them. The bedrock, however, does not seem suitable for this and water storage will probably have to be at the surface.

BRINES

An important potential source of mineral wealth for Erie County is the salt beds or salt waters contained within various formations below the surface.

It may be possible to use a process such as the Frasch Process of the sulfur industry to mine rock salt from below the Erie surface. In this process hot water is pumped down one well to dissolve the salt to form brine; the brine is then pumped up at another location.

Salt water under the county has been detected by gas well operations in the Oriskany sandstone, Salina Group, Medina sandstone, Trenton Group, and the Gatesburg Formation. The analysis of brines reported by Poth (See reference list) involves the Oriskany, the Salina, and the Gatesburg.

Unit	Altitude of well	Aquifer depth	Aquifer composition	Dissolved parts per million
Oriskany	893	1997 ft.	sandstone	256,000
Salina	883	2320 ft.	anhydrite and dolomite	155,380
Gatesburg	1240	5970 ft.	dolomite	265,000

The major chemical ions in order of decreasing abundance were chlorides, sodium, and calcium. Minor ions of importance were magnesium, potassium, and bromides. Trace elements included iron, manganese, copper, zinc, lithium, fluorine, and iodine. Significant among the ions of the brines was the potassium which was reported here in greater abundance than in any other county in Pennsylvania except Clearfield which has brines equal in potassium content.

Almost every gas well drilled in the county had a show of salt water at some point along the way. In a well near McKean salt water rose to a height of 1883 feet in the casing before the well was abandoned. The water was discovered at a depth of 2170 feet in the Oriskany Formation. Many of the Summit Township wells were abandoned with accumulations of salt water. Here also the waters rose rapidly in many of the casings. A rapid brine producing well was drilled in Greenfield Township near the headwaters of Six Mile Creek. It produced 95 gallons of brine in 1½ hours. This well has been capped and set aside for possible future brine production.

Subsurface brines are believed to have originated from the concentration of sea waters trapped in the sediments at the time of deposition. Some are also believed to have originated by percolating waters dissolving salts as they passed through aquifers rich in soluble materials. These gathered in pools and were concentrated by ion exchange with surrounding rock.

Brines are processed in many states. Texas processers obtain the following salts; sodium chloride, calcium chloride, and magnesium chloride. In the process bromides and iodides are obtained as a by-product. Various gases are also obtained by the electrolysis of brines.

It is conceivable that in the future brines will be abundantly processed in Erie County. Today Erie County brines are only used in producing salt for icy roads. In many integrated industries salts are a necessity and with the manufacture of inexpensive extracting processes such salt-using industries may find it profitable to locate in Erie County.

SOILS

The soils of Erie County have nearly all developed on glacial materials and as such are relatively young soils. The distribution and character of the county's soils are well shown in a report prepared by the U. S. Soil Conservation Service (See reference list).

Like most Pennsylvania soils, the Erie County soils are acid; though, in southwest Erie County lime occurs in the subsoil within 2 or 3 feet of the surface. Soil character strongly reflects the character of its parent material. The sandy soils of the lake plain are found on sandy beaches; gravelly soils exist on kames; and fine-grained, slow-draining soils cover the Hiram and Lavery till areas.

FORESTS AND WOODLANDS

In 1961 approximately 129,300 acres in the county were in forests. Of these, 700 were noncommercial woodlands. The county contains 519,700 acres of land, so approximately one-fifth of the county is wooded.

More than half of the wooded area contained hardwoods with oak making up about a fifth of this number. The timber reserves of the county are regulated by state and federal agencies which control cutting quotas.

Much of the upland is now used for growing conifers for sale as Christmas trees. Many of the trees have passed the harvesting stage and are now growing into larger trees that may be put to other uses.

The State Game Commission has also distributed several million evergreen seedlings to farmers of the plateau area for conservation and game cover purposes. These will provide a cash crop to the farmers in years to come.

There are many small logging operations carried on within the county in both winter and summer. The harvesting slacks off in the fall and spring due to soggy ground conditions which make passage of heavy machinery difficult. The smaller operators sell their product to processing mills by contract or through newspaper advertisements. The larger operators sell strictly by contract to larger consumers.

The largest single producer of timber in the county is the Hammermill Paper Company which derives 67 percent of its raw materials from Pennsylvania sources. The company owns 137,000 acres of Pennsylvania woodlands. The mill, which pioneered hardwood pulpwood, buys between six and seven thousand standard cords of hardwoods from county sources in an average year.

Other industries which use county timber include lumber mills, plastic fabricators, furniture mills, and boat oar manufacturers.

WILDLIFE AND FISH

There are 8,982 acres of state game lands in the county and upon these may be found every legal game animal in Pennsylvania. There were 26,023 hunting licenses and 21,055 fishing licenses sold in 1960. The previous year hunters harvested 175 antlered and 299 antlerless deer from county woodlands. Trappers sold 195 beaver pelts.

For the fisherman there were 25,880 trout stocked in Erie's streams to add to the bass, muskellunge, sucker, smelt, and trout already in the waters. Natural trout are abundant in Lake Pleasant. Muskellunge of trophy size are often taken from the waters of Lake Le Boeuf and Lake Edinboro.

The State Fish Commission maintains fish hatcheries at Union City, Erie, and two at Corry. Special stream projects are also underway at Corry and Elgin. Stream, lake, and reservoir access areas have been purchased at Elgin, Corry, North East, Union City, Manchester Beach, Waterford, and Lake City. The purpose of access areas is to provide free access to boaters and fishermen who would otherwise be required to pay launching fees or be deprived of using the county waters.

In 1963 there were 25 commercial fishing vessels on Lake Erie licensed to fish in Pennsylvania waters (Figure 39). Fish catches have

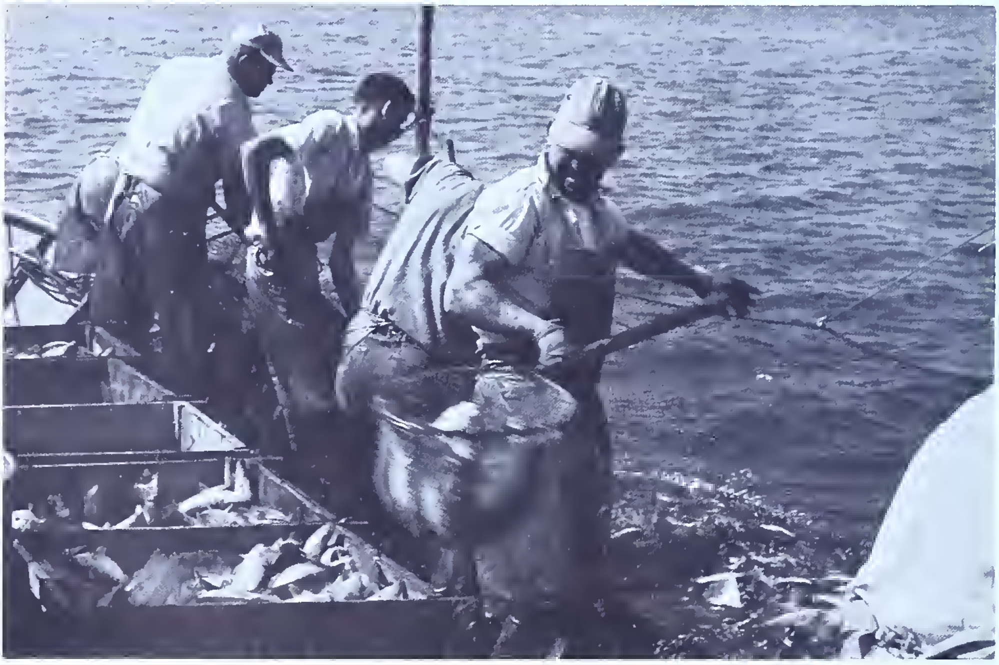


Figure 39. Fishermen of the Ralph Fisheries bring in a catch (Photographed by Pennsylvania Fish Commission).

decreased dramatically each year and unless measures are taken this trend will continue. The Ralph Fisheries of Manchester Beach have purchased several hundred acres of land in Crawford County. Here they have built ponds in which they raise commercially desirable fish to supplement their lake catches.

In 1962 the total fish catch reported by commercial fish companies fishing in Pennsylvania waters was 2,145,464 pounds. This catch had a total wholesale value of $150,253. The fish species and weight in pounds for the 1962 catch were as follows; Yellow Perch 2,041,913 lbs., Smelt 73,411 lbs., White Bass 10,521 lbs., Sheephead 7,930 lbs., Walleye 4,807 lbs., Red Horse 2,871 lbs., Catfish 1,267 lbs., White Fish 1,140 lbs., Carp 1,006 lbs., Blue Pike 512 lbs., Cisco or Herring 334 lbs., Burbot 291 lbs., White Sucker 100 lbs., and Bullheads 81 lbs.

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